



# **CODE OF PRACTICE ON RADIATION PROTECTION IN INDUSTRIAL RADIOGRAPHY**



Lembaga Perlesenan Tenaga Atom  
Kementerian Sains, Teknologi dan Inovasi  
Batu 24, Jalan Dengkil, 43800 Dengkil  
Selangor Darul Ehsan

Tel: 03-89225888  
Fax: 03-89223685 / 03-89254578  
Web Site: <http://www.aelb.gov.my>

# CODE OF PRACTICE ON RADIATION PROTECTION IN INDUSTRIAL RADIOGRAPHY

## TABLE OF CONTENTS

**Page**

### PART I INTRODUCTION

|    |   |   |
|----|---|---|
| 1. | Purpose of Code of Practice                   | 1 |
| 2. | Specialized Meanings for “shall” and “should” | 1 |
| 3. | Definitions                                   | 1 |

### PART II ADMINISTRATIVE PROCEDURES

#### *Chapter 1: Compliance With Legal Requirements*

|    |  |   |
|----|--|---|
| 4. | The Relevant Act and Subsidiary Legislations | 3 |
| 5. | Licence Requirement                          | 4 |

#### *Chapter 2: Responsibilities of Persons Involved in Industrial Radiography*

|     |   |    |
|-----|---|----|
| 6.  | Responsibilities of a Licensee  |    |
| 6.1 | Compliance with Licence Conditions  | 4  |
| 6.2 | Protection of Workers and Members of the Public                                   | 4  |
| 6.3 | Establishment and Implementation of a Radiation<br>Protection Programme           | 5  |
|     | 6.3.1 Establishment of a Radiation Protection Programme                           | 6  |
|     | 6.3.1.1 Organizational Structure Pertaining to<br>Radiation<br>Protection         | 6  |
|     | 6.3.1.2 Employment of a Radiation Protection<br>Officer                           | 8  |
|     | 6.3.1.3 Medical Surveillance of a Worker  | 9  |
|     | 6.3.1.4 Personal Monitoring   | 9  |
|     | 6.3.1.5 Area Monitoring   | 10 |
|     | 6.3.1.6 Operational Limit   | 11 |
|     | 6.3.1.7 Classification of Working Areas and<br>Setting Up<br>of Barriers          | 11 |
|     | 6.3.1.8 Normal Working Procedures   | 11 |
|     | 6.3.1.9 Procedures for Transportation of a<br>Package<br>Containing Sealed Source | 11 |
|     | 6.3.1.10 Procedures Under Normal Conditions                                       | 12 |
|     | 6.3.1.11 Training of a Worker   | 13 |
|     | 6.3.1.12 Procedures for Keeping and Transferring<br>Records / Document            | 13 |
|     | 6.3.2 Implementation of a Radiation Protection<br>Programme                       | 13 |

|  |    |
|--|----|
| 6.3.2.1 Arrangement for the Service of an<br>Approved<br>Registered Medical Practitioner | 16 |
|--|----|

### **PART III**

#### **RADIOGRAPHIC EQUIPMENT SAFETY DEVICES**

##### *Chapter 3: Radiographic Equipment*

|            |   |    |
|------------|---|----|
| <b>10.</b> | General Requirements                              | 17 |
| <b>11.</b> | Apparatus for X Radiography                       | 17 |
| 11.1       | General Requirements                              | 17 |
| 11.2       | Regular Inspection of the X-Ray Equipment         | 17 |
| <b>12.</b> | Apparatus for Gamma Radiography                   | 18 |
| 12.1       | General Requirements                              | 18 |
| 12.2       | Maintenance of an Apparatus for Gamma Radiography | 20 |
| <b>13.</b> | Pipeline Crawler Equipment                        | 21 |

##### *Chapter 4: Safety Devices*

|            |                                       |    |
|------------|---------------------------------------|----|
| <b>14.</b> | General                               | 22 |
| <b>15.</b> | Approved Personnel Monitoring Devices | 23 |
| <b>16.</b> | Survey Meter                          | 23 |
| <b>17.</b> | Warning Sign                          | 23 |
| <b>18.</b> | Notices                               | 28 |

### **PART IV**

#### **NORMAL WORKING PROCEDURES**

##### *Chapter 5: Planning A Working Procedure*

|            |                                 |    |
|------------|---------------------------------|----|
| <b>19.</b> | General                         | 29 |
| <b>20.</b> | Radiographic Sites              | 29 |
| <b>21.</b> | Prior to Radiographic Operation | 29 |
| <b>22.</b> | During Radiographic Operation   | 36 |
| <b>23.</b> | After Radiographic Operation    | 36 |

##### *Chapter 6: Planned Special Exposure*

|            |                      |    |
|------------|----------------------|----|
| <b>24.</b> | General Requirements | 36 |
|------------|----------------------|----|

##### *Chapter 7: Storage*

|            |  |    |
|------------|--|----|
| <b>25.</b> | Storage of Apparatus for X Radiography | 37 |
| <b>26.</b> | Storage of a Sealed Source             | 37 |
| 26.1       | General                                | 38 |
| 26.2       | Storage Pit                            | 38 |
| 26.3       | Storage Room                           | 39 |
| 26.4       | Storage Enclosure                      | 39 |
| 26.5       | Temporary Storage Vehicle              | 39 |

## *Chapter 8: Source Changing*

|     |                    |    |
|-----|--------------------|----|
| 27. | General Procedures | 40 |
|-----|--------------------|----|

### **PART V TRANSPORTATION OF A PACKAGE CONTAINING SEALED SOURCE**

|     |                    |    |
|-----|--------------------|----|
| 28. | General Procedures | 41 |
|-----|--------------------|----|

## *Chapter 9: Packaging*

|     |  |    |
|-----|--|----|
| 29. | General  | 41 |
| 30. | Receiving of a Packaging Containing Sealed Source        | 41 |
| 31. | Labeling of a Packaging Containing Sealed Source         | 42 |
| 32. | Requirements for Import/Export of Radiographic Equipment | 42 |

## *Chapter 10: Requirements for Transportation of a Package Containing Sealed Source*

|     |   |    |
|-----|---|----|
| 33. | General   | 44 |
| 34. | Transportation of a Package Containing Sealed Source by Road                          | 45 |
| 35. | Transportation of a Package Containing Sealed Source by Sea or Inland Waterway Vessel | 47 |
| 36. | Transportation of a Package Containing Sealed Source by Air                           | 47 |

### **PART VI PROCEDURES UNDER ABNORMAL SITUATIONS**

## *Chapter 11: General Requirements*

|     |  |    |
|-----|--|----|
| 37. | Reporting                                      | 48 |
| 38. | Equipment to be Used Under Abnormal Situations | 48 |

## *Chapter 12: Procedures Under Abnormal Situations With Radiographic Equipment While In Operation*

|     |                          |    |
|-----|--------------------------|----|
| 39. | X-Ray Equipment          | 48 |
| 40. | Sealed Source            | 49 |
| 41. | Pipeline Crawler Machine | 51 |

## *Chapter 13: Procedures Under Abnormal Situations With Radiographic Equipment While Not In Operation*

|     |  |    |
|-----|--|----|
| 42. | Damage or Malfunction  | 51 |
| 43. | Sealed Source Involved in Fire                                 | 51 |
| 44. | Theft or Loss of Radiographic Equipment                        | 52 |
| 45. | Accident While Transporting a Package Containing Sealed Source | 52 |

## *Chapter 14: Overexposure*

|            |                           |    |
|------------|---------------------------|----|
| <b>46.</b> | General Requirements      | 53 |
| 46.1       | For Workers               | 53 |
| 46.2       | For Members of the Public | 53 |
|            | References                | 54 |
|            | Appendix                  | 64 |

## **PART I INTRODUCTION**

### **1. Purpose of Code of Practice**

- (a) The purpose of this Code of Practice is to provide minimum requirements for radiation protection in the use of x and gamma rays in industrial radiography.

### **2. Specialized meanings for "shall" and "should"**

The words shall and should, where used in this Code, have specialized meanings: "Shall" indicates that the particular requirement is to be complied with. "Should" indicates that the particular requirement is to be complied, wherever practicable to further improve the situation or performance.

### **3. Definitions**

"abnormal situation" means any event which may cause over exposure to workers and members of the public [P.U (A)61 Reg.3];

"apparatus for gamma radiography" means an apparatus, including its exposure container and accessories, designed to enable gamma radiation emitted by a sealed source to be used for industrial radiography;

"Board" means the Board established under section 3 of the Atomic Energy Licensing Act 1984 [Act 304 Sec .3];

"calibrated" means an instrument, component or system that has undergone the measurement of, or adjustment to, to ensure its accuracy or response is acceptable and the processes are performed by an agency recognized and approved by the appropriate authority;

"collimator" means a device to limit a useful beam to the required cross-sectional area of interest;

"controlled area" means any area in which specific protection measures and safety provisions are or could be required for controlling normal exposures or preventing the spread of contamination during normal working condition, and preventing or limiting the extent of potential;

"exposure container" means a shield in the form of a container designed to allow controlled use of gamma radiation and employing one or more sealed sources;

"fully enclosed site" means an enclosed site such as a shielded room, the boundary of which is formed wholly by suitably designed physical barriers and access is controlled by physical barriers;

"Half-Value-Layer (HVL)" means thickness of a certain material required to reduce radiation of a known energy range and intensity, to half of its original intensity. This can also be expressed as the quotient of 0.693 by the linear attenuation coefficient of the material;

"industrial radiography" means a non-destructive technique of examining structure of materials utilizing x-rays, neutron or gamma rays;

"interlock" means a device or system for precluding access to an area of radiation hazard either by preventing entry or by automatically stopping the exposure;

"leak test" means a technique for checking the escape of radioactive material from the source capsule;

"leakage radiation" means all radiation emitted from the exposure container or x-ray tube housing other than the useful beam;

"open site" means a site, where the boundary of the controlled area is formed by physical barriers, but access to the area is not prevented by these physical barriers alone;

"partly enclosed site" means an enclosed site, the boundary of which lies wholly or partly outside the suitably designed physical barriers;

"package" means packaging with radioactive contents as presented for transport;

"person" means any individual, partnership, private or public body whether corporate or not, institution or organization, or any international body, institution or organization enjoying legal personality;

"planned special exposure" means voluntary exposure during normal operation whereby one or more of the annual dose limits for a worker are likely to be exceeded, permitted only in situations when alternative techniques, which do not involve such exposure, cannot be used [P.U (A)61 Reg.3];

"public area" means the area which is normally visited or occupied by members of the public;

"radiographic equipment" includes x-ray equipment for industrial radiography, apparatus for gamma radiography and pipeline crawler equipment;

"source" means any material or irradiating apparatus which emits x or gamma radiation suitable for industrial radiography;

"shutter" means a device fixed to the x-ray tube housing or exposure container capable of intercepting the useful beam;

"source changer" means a device designed and used for replacement of sealed source in an exposure container;

"special arrangement" means an arrangement, approved by the Board, under which a consignment which does not fully satisfy the applicable requirements of these Regulations may be transported;

"Tenth-Value-Layer (TVL)" means the thickness of a certain material required to reduce the radiation of a known energy range and intensity, to one-tenth of its original intensity. This can also be expressed as the quotient of 2.303 by the linear attenuation coefficient of the material;

"useful beam" means that part of the radiation which passes through the window, aperture, cone or other collimating device of the x-ray tube or exposure container;

"worker includes any person working under the instruction of the licensee, whether or not employed by the licensee, in the handling or use of, or who will come into contact with, any radioactive material or irradiating apparatus [P.U (A)61 Reg. 3].

## **PART II**

### **ADMINISTRATIVE PROCEDURES**

#### *Chapter 1: Compliance With Legal Requirements*

#### **4. The Relevant Act and Subsidiary Legislations**

##### **4.1 Radiation protection in industrial radiography activities in Malaysia are governed by the following legal instruments:**

- (a) The Atomic Energy Licensing Act 1984 (Act 304)
- (b) The Radiation Protection (Licensing) Regulations 1986 (P.U.(A) 149)
- (c) The Radiation Protection (Basic Safety Standards) Regulations 1988 (P.U.(A) 61)
- (d) The Radiation Protection (Transport) Regulations 1989. (P.U.(A) 456).

##### **4.2 The Atomic Energy Licensing Act 1984 is the principle law while the Radiation Protection (Licensing) Regulations 1986, the Radiation Protection (Basic Safety Standards) Regulations 1988 and the Radiation Protection (Transport) Regulations 1989 are the subsidiary legislations made under it. The Radiation Protection (Basic Safety Standards) Regulations 1988 and the Radiation Protection (Transport) Regulations 1989 specify the operational safety requirements, while the Radiation Protection (Licensing) Regulations 1986 specifies the requirements to obtain a licence.**



- 4.3 A licence issued for industrial radiography is provided with conditions of licence, which shall be complied with [Act 304 Sec.17].

## 5. Licence Requirement

Any person who wishes to practice industrial radiography shall obtain a licence for:

- (a) Class A (sealed source)
- (b) Class C (x-ray equipment)
- (c) Class D (transport)

as applicable to the proposed activities, from [Act 304 Sec.12 (1)].

### *Chapter 2: Responsibilities of Persons Involved in Industrial Radiography*

## 6. Responsibilities of a Licensee

### 6.1 Compliance with Licence Conditions

The licensee shall comply with licence conditions and the relevant provisions of the Atomic Energy Licensing Act 1984 and its subsidiary legislations [Act 304 Sec.17].

### 6.2 Protection of Workers and Members of the Public

The licensee shall ensure that the annual dose limits (ADLs) specified in Table 1 are not exceeded.

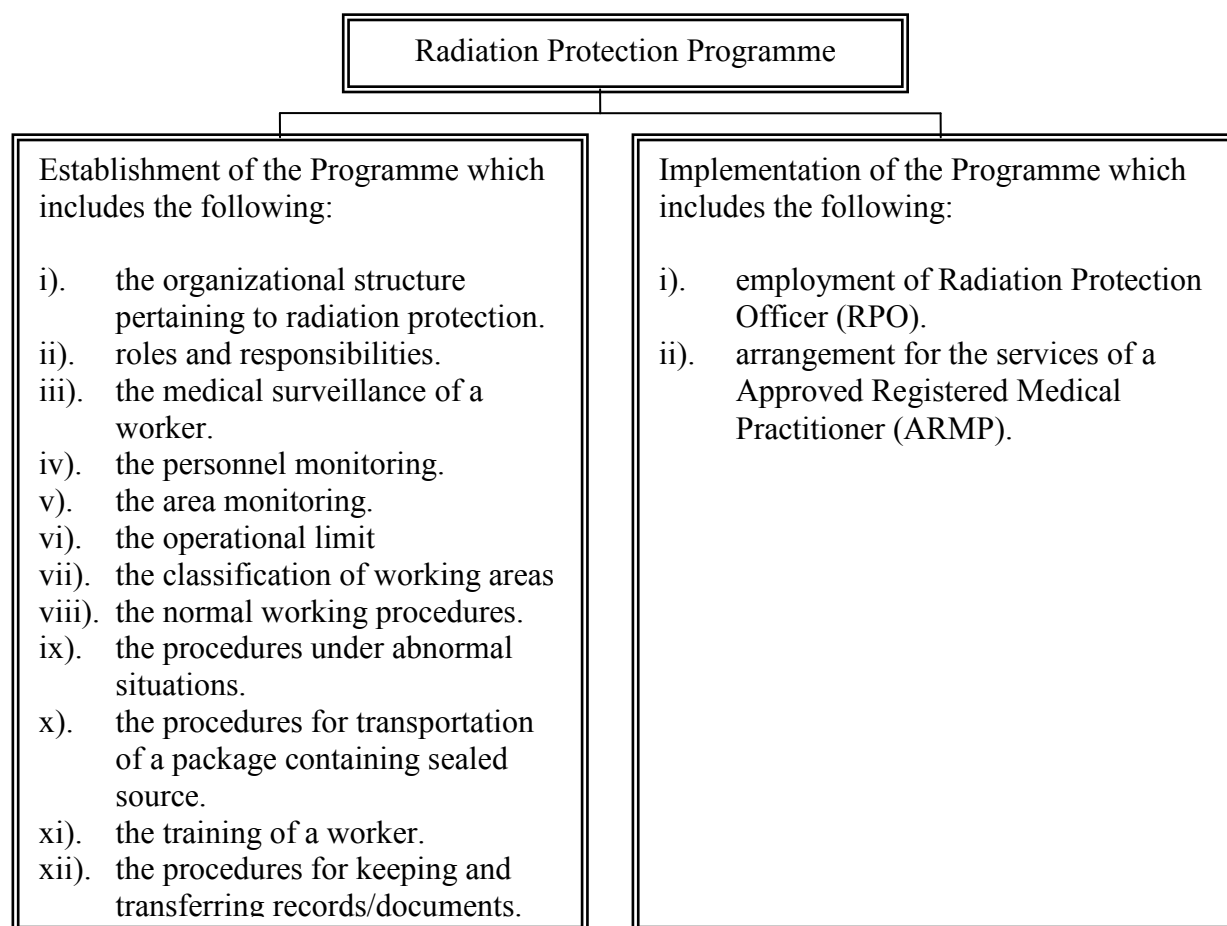
**Table 1:** *Annual Dose Limits (ADLs).*

| Types of Exposure                                    | Dose (mSv)          |
|--|---------------------|
| EXPOSURE OF WORKERS                                  |                     |
| Whole body exposure                                  | 20 <sup>1/ 2/</sup> |
| Partial body exposure                                | 50                  |
| (average dose for each organ except lens of the eye) | 500                 |
| (average dose for lens of the eye)                   | 150                 |
| Planned special exposure                             |                     |
| Over one calendar year                               | 2 x ADL             |
| Over life time                                       | 5 x ADL             |
| EXPOSURE OF THE MEMBERS OF THE PUBLIC:               |                     |
|  | 1 <sup>3/</sup>     |
|  | 50 <sup>4/</sup>    |
| Whole body exposure                                  |                     |
| Partial body exposure                                |                     |

- 1/ For a female worker of reproductive capacity, any exposure shall be as uniformly distributed with time as is practicable.
- 2/ For a pregnant worker, the dose to the foetus accumulated over a period of between the confirmation of pregnancy and the date of delivery shall not exceed 1 mSv.
- 3/ The limit shall be 5 mSv where the person is likely to be exposed at or near the limit for many years provided that the average annual dose over the life time does not exceed 1mSv.
- 4/ The limit applies to the skin and lens of the eye only. Others organs have no limits for such organs are already made inherently safe in the setting up of the whole body limit.

### 6.3 Establishment and Implementation of a Radiation Protection Programme

The licensee shall establish and implement a radiation protection programme shown in Figure 1[P.U.(A)149 Regs. 12 and 13).



**Figure 1:** *Outline of Establishment and Implementation of a Radiation Protection Programme*

### 6.3.1 Establishment of a Radiation Protection Programme

The programme shall be consistent with provisions of the Act and any subsidiary legislations made thereunder, which shall include:

#### 6.3.1.1 Organizational Structure Pertaining to Radiation Protection

The licensee shall establish the overall organizational structure pertaining to radiation protection and shall include specific delegation of authority and responsibility for the radiographic operations.

For the purpose of Radiation Protection Programme, radiation personnel shall be specified as Radiation Protection Officer, Radiation Protection Supervisor, Operator, and Trainee Operator whose responsibilities as follows:

##### *a) Responsibilities of Radiation Protection Officer (RPO)*

In general, a RPO appointed pursuant to the Act 304 for the activities of industrial radiography shall implement a radiation protection programme as specified in Figure 1 in paragraph 6.3[P.U.(A)61Reg.3 and P.U.(A)149 Reg.12(b)].

Notwithstanding the requirement of such a programme, the RPO shall also [P.U.(A)61Reg. 3].

- i). Implement safe working procedures for:
  - a. Normal operation, including storage and source changing (as in Part IV)
  - b. Transportation of a package containing sealed source (as in Part V).
  - c. Abnormal situations (as in Part VI).
- ii). Supervise the implementation of appropriate radiation protection Regulations, measures and procedures [P.U.(A)61Reg. 3].

##### *b) Responsibilities of Radiation Protection Supervisor*

The Radiation Protection Supervisor (RPS) shall carry out the following duties:

- i). to carry out RPO's duties during his absence and to report to him when he returns to work.
- ii). to assist RPO in complying with the requirements of the Act 304 and its subsidiary legislations.

*c) Responsibilities of an Operator*

The principal responsibilities of an operator includes the following:

- i). shall be thoroughly familiar with the normal working procedures and procedures under abnormal situations [P.U.(A)61Reg.5(1)].
- ii). shall comply with radiation protection programme, safe working procedures and instructions given; and refrain from careless and reckless practices or actions that may result in unnecessary exposure to himself or others [P.U.(A)61Reg.54(1)].
- iii). shall ensure that he is equipped with a film badge, other optional approved personnel monitoring devices as required (see Table 3) and a survey meter, at all times while engaged in radiographic operations [P.U.(A)61Reg.54(3)].
- iv). He shall take all reasonable precautions to prevent damage to equipment and keep it in good operating condition [P.U.(A)61Reg.54(4)].
- v). Unless duly authorized, he shall not interfere with any method or process adopted for the control of exposure to ionizing radiation [P.U.(A)61Reg.54(4)].
- vi). He shall use, as instructed, all facilities provided to minimize radiation exposure [P.U.(A)61Reg.54(2)].
- vii). He shall notify the RPO or the supervisor immediately in the event of any accident or incident [P.U.(A)61Reg.54(5)].
- viii). He shall notify the RPO or the supervisor immediately if his film badge, pocket dosimeter or audible alarm monitor is lost, damaged or observed to be off scaled [P.U.(A)61Reg.54(5)]
- ix). He shall always check the exposure container with a survey meter before it is moved or put into operation to ensure that the source is in its secured and shielded position [P.U.(A)61Reg.54(1)]
- x). In any abnormal situations, he shall take necessary steps in accordance with the established procedures and he shall immediately inform the RPO or the supervisor [P.U.(A)61Reg.54(5)]
- xi). To strictly and closely supervise a trainee operator when operating radiographic equipment.

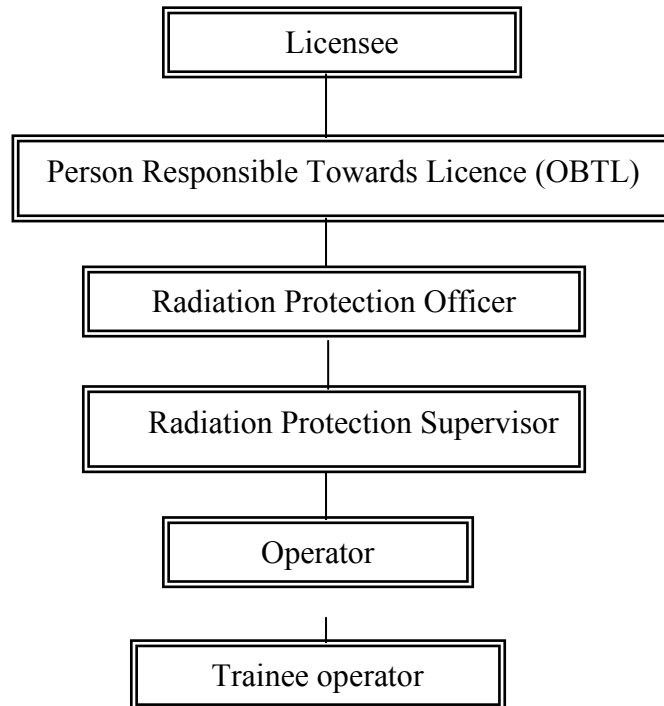
*d) Responsibilities of Trainee Operator*

The responsibility of trainee operator is to assist an operator in performing industrial radiography activity.

e) Joint Responsibilities

When work is done jointly by a number of workers, they shall understand their own joint responsibilities for controlling the exposure to others as well as themselves and that they shall be adequately supervised by RPO or RPS [P.U.(A)61Reg.54].

*Chart 1: Example of Organization Chart*



6.3.1.2 Employment of Radiation Protection Officer (RPO)

The licensee shall employ a Radiation Protection Officer (RPO) and an operator whose responsibilities are described in paragraphs 6.3.1.1 [P.U. (A) 61 Reg. 23 & P.U (A) Reg. 12(1)]:

- a) Radiation protection officer (RPO) is a technically competent person appointed by the licensee and approved by the Board in writing, to supervise the implementation of appropriate radiation protection Regulations; measures and procedures including the radiation protection programme [P.U. (A) 61 Reg. 23]. In the event, that the service of RPO cease for some reasons, licensee shall appoint a new RPO. An RPO could be an RPS or consultant approved by the Board.
- b) Operator is a worker who is recognized in writing by the Board to perform the radiographic operations, under the supervision of a RPO or a Radiation Protection Supervisor (RPS). In order to get recognition from the Board, the worker shall pass the examinations recognized by the Board and shall comply with the directives issued by the Board from time to time [P.U.(A) 149 Reg.12(1)].

In addition, the licensee should also employ a Radiation Protection Supervisor (RPS) and trainee operator [P.U.(A) 149 Reg.12(1)].

- c) Radiation Protection Supervisor (RPS) is a technically competent person appointed by the licensee and approved by the Board in writing to assist the RPO in supervising the implementation of the appropriate radiation protection Regulations, measures and procedures including the radiation protection programme. A RPS shall be at least an operator [P.U.(A) 149 Reg.12(1)].
- d) Trainee operator is a worker whose duty is to assist an operator. He is allowed to operate the radiographic equipment under strict and close supervision by an operator. [P.U.(A) 149 Reg.12(1)].

#### 6.3.1.3 Medical Surveillance of a Worker

The licensee shall ensure that medical surveillance of a worker is carried out as in Table 2 [P.U.(A) 61 Reg.32, 35, 36, 37, 38, 39 and 42]

**Table 2: Medical surveillance of a worker**

|  |
|--|
| Pre-employment medical examination <sup>1/</sup>                             |
| Periodic review of health <sup>2/</sup>                                      |
| Medical examination at termination of employment or retirement <sup>3/</sup> |
| Special medical examination <sup>4/</sup>                                    |

1/ To be carried out prior to employment.

2/ To be carried out at least once in two years.

3/ To be carried out not later than 14 days after cessation of employment.

4/ To be carried out

- (i) whenever the worker receives dose exceeding ADLs
- (ii) more frequently if the worker's exposure conditions and state of health so requires.
- (iii) Reason to believe that the person has been exposed to radiation due to abnormal situation.

#### 6.3.1.4 Personal Monitoring

Any authorized non-radiation worker who enters a controlled area shall wear a personal dosimeter. But radiation worker shall wear either a thermoluminescent dosimeter (TLD) or a film badge. [P.U.(A)61 Reg.26(1)]. However, other approved personnel monitoring devices for assessment of external exposures may also be worn (see Table 3) [P.U.(A)61 Reg.26(1)]. All accumulated dose shall be recorded and documented.

**Table 3:** Approved Personal Monitoring Devices for Assessment of External Exposures

| Monitoring Device               | Requirement of Wearing  |
|---------------------------------|---|
| Film Badge, TLD <u>1/</u>       | Mandatory for RPO, supervisor, operator and trainee operator. |
| Pocket Dosimeter <u>2/</u>      | Optional for RPO, supervisor, operator and trainee operator.  |
| Audible Alarm Monitor <u>3/</u> | Optional for RPO, supervisor, operator and trainee operator.  |

1/ The device should be worn visibly at chest or waist level.

2/ The device should be worn at chest level.

3/ The device shall be worn on chest level. It shall be capable of giving a recognizable signal at dose rate of  $0.1\text{mSv/h} \pm 50\%$  It shall be kept switched on during radiographic operation.

For all workers, the sum of doses of X-ray and gamma rays received in one calendar year shall be as low as reasonably achievable and shall not exceed any of the ADL's prescribed in Table 1 in paragraph 6.2 [P.U.(A)61 Reg. 6(1), 8, 9, 10, 11 and 12].

#### 6.3.1.5 Area Monitoring

Area monitoring for the supervised and controlled areas associated with fully enclosed, partly enclosed and open sites shall be done for the following cases [P.U (A)61 Reg.25]:

- a) Before the operation.
- b) During the operation.
- c) After the operation.
- d) To review the foreseeable types of accidents.

Table 4 indicates recommended methods of area monitoring for external exposures in the fully enclosed, partly enclosed or open site industrial radiography and recommended method for recording accumulated dose on the surrounding area of a fully enclosed site.

**Table 4:** Recommended method of area monitoring for external exposures.

| Modes of monitoring   | Monitoring devices  | Objectives   |
|---|---|--|
| Survey <u>1/</u><br>to be carried out before, during and after operations.    | Portable survey meter, containing a suitable detector (e.g. compensated GM).    | To measure and record ambient radiation dose rates.                                  |
| Continuous monitoring <u>2/</u><br>with monthly changes of monitoring device. | Integrating dosimeter, such as film badge or thermo luminescent dosimeter (TLD) | To record accumulated dose in the surrounding areas (i.e outside the exposure room). |

- 1/ To be carried out in fully enclosed, partly enclosed or open site industrial radiography.
- 2/ To be carried out in the outside area of fully enclosed site industrial radiography only and the monitoring device is recommended to be placed on the outside physical barriers.

In addition, area monitoring for the supervised and controlled areas in a fully enclosed site, shall also be done for the following cases [P.U.(A)61 Reg. 25]:

- a) Before starting operation in a new facility.
- b) Whenever there are, or may have been fundamental changes to the pre-existing facility.
- c) When practical changes in the protection system in working process have been made.

#### 6.3.1.6 Operational Limit

The licensee shall establish an operational limit which is a dose constraint, lower than the ADL that shall not be exceeded during operation. It shall be established by the licensee and subject to the approval from the Board [P.U.(A)61 Reg.2 & 47].

The Board recommends 18 mSv/year as the operational limit. However, in all cases the licensee shall apply ALARA principle [P.U.(A)61 Reg.5].

In the event, the limit being exceeded the licensee shall inform the Board of the occurrence [P.U.(A)61 Reg.55].

#### 6.3.1.7 Classification of Working Areas and Setting Up of Barriers.

The licensee shall ensure that classification of working areas and setting up of barriers are carried out as in Table 5 [P.U.(A)61 Reg. 24].

#### 6.3.1.8 Normal Working Procedures

The licensee shall establish normal working procedures with respect to the proposed activity to be carried out (as in Chapter 4) [P.U.(A)149 Reg. 12(b)].

#### 6.3.1.9 Procedures for Transportation of a Package Containing Sealed Source

The licensee shall establish procedures for transportation of a package containing sealed source in accordance with the Radiation Protection (Transport) Regulations 1989 and any other relevant Regulations pertaining to it (as in Chapter 5) [P.U.(A)149 Reg.12(b)].



**Table 5:**      *The Requirements for Radiographic Sites*

|                    | <b>SITES</b>  |  |
|--------------------|---|--|
|                    | <b>Fully Enclosed</b>   | <b>Partly Enclosed/Open</b>  |
| Choice of the site | Prior approval for the proposed design and siting of the exposure room shall be obtained from the Board before any radiographic work is undertaken.   | Should be out of the vicinity of the public whenever possible.<br><br>Exposure limit shall not be exceeded.  |
| Supervision        | Should be under direct control of a licensee.   | Shall be under supervision of an RPO or an RPS.  |
| Boundary/barrier   | <p>It shall be constructed of solid building material (i.e, concrete, etc).</p> <p>The dose rate at any point outside the external wall including doors or adjoining area should not exceed 2.5 <math>\mu\text{Sv/h}</math>.</p> <p>The warning signs, notices and signals (lights) shall be installed at all accessible wall.</p> <p>The warning signal should be actuated before and until completion of the operation.</p> | <p>Shall be defined at a controlled area (i.e. 7.5 <math>\mu\text{Sv/h}</math> at the barrier).</p> <p>Appropriate warning signs and notices shall be provided at the boundary.</p> <p>Workers should be outside the barrier, i.e during radiographic operation. The RPO and RPS shall not enter supervised and controlled areas except in case of gamma radiography, during winding out and winding in radiography source</p> |
| Interlock          | <p>Effective interlocks that are foolproof and designed to fall-to-safety shall be provided.</p> <p>Suitable means of exit shall be provided.</p> <p>In the event of an exposure being terminated by an interlock, it be possible only to reinitiate the operation from the control panel.</p> <p>The control panel of any x-ray unit shall be so wired that it cannot be operated, unless the door is fully closed.</p>      |  |
| Notes              | The source activity used in the exposure room shall not be greater than what has been approved  |  |

#### 6.3.1.10 Procedures Under Abnormal Situations

The licensee shall establish procedures to be used under abnormal situations with respect to the proposed activity to be carried out (as in Chapter 6) [P.U.(A)149 Reg. 12(b)].

#### 6.3.1.11 Training of a Radiation Worker

Every worker shall be thoroughly trained and familiarized with [P.U.(A)61 Reg. 49(1)].

- a) The sources of radiation radiographic and ancillary equipment associated with his job and be able to recognize its malfunction.
- b) His duties and responsibilities.
- c) The potential health risks of work with ionizing radiations and the need for appropriate safe practices.
- d) Measurement methodology of the ionizing radiations.
- e) Radiation protection methods and compliance with the provisions of the Radiation Protection (Basic Safety Standards) Regulations 1988.
- f) Normal working procedures.
- g) Procedures under abnormal situations.

The appropriate retraining and updating of skill and knowledge of the workers shall be provided at least once in every three years [P.U.(A)61 Reg.49(2)].

#### 6.3.1.12 Procedures for Keeping and Transferring Records/Documents.

- a) All records or documents as listed in Table 6 shall be kept and made available for inspection at licensee's premise, to the SPO [P.U.(A)61 Reg.55].
- b) When a worker ceases to be employed by the licensee, his medical record shall be submitted to the Board. [P.U.(A)61 Reg.45(5)].
- c) When a new worker joins the licensee, after working as a radiographer or other work with ionizing radiation elsewhere, the licensee shall obtain the medical record from the Board [P.U.(A)61 Reg.45(7)].
- d) The licensee who ceases operations shall submit medical records of all workers to the Board for retention [P.U.(A)61 Reg. 45(6)].

#### 6.3.2 Implementation of a Radiation Protection Programme

To implement the radiation protection programme, the licensee shall employ an RPO whose responsibilities as given in para 6.3.1.1 [P.U.(A)61 Reg. 23(1)].

**Table 6:** *Records / Documents to be Kept in Carrying Out Activities Related to Industrial Radiography*

| Records Documents to be kept      |  | Form to be used                       | Duration of maintenance confidentiality  | Notes  |
|-----------------------------------|--|---------------------------------------|--|--|
| Valid licence issued by the Board | 1. Class A licence.<br>2. Class C licence.       | Licence issued by the Board.          | Shall be kept as long as licence is valid  | A copy of a licence shall be make available for inspection at premises or radiographic sites.  |
| Medical record of a worker        | 3. Medical record (Section A)                    | LPTA/BM/5 (as provided by the Board). | Shall be kept as long as he remains as a worker  | Shall transfers the medical records of workers to the Board once the licensee ceases operations.   |
|                                   | 4. Exposure record (Section B)                   |                                       | Shall be kept for 30 years after the retirement or termination of his employment after which it shall be transferred to the Board<br><br>The former licensee shall submit the medical record when requested by the new licensee.<br><br>Shall be confidential. | In case of exposure to a worker exceeding the annual dose limit, the result shall be submitted to an ARMP and the Board.<br><br>The worker concerned shall be informed of the results in writing not later than 2 weeks after the results are available. |
| For all sealed sources            | 5. Return of possession of radioactive material. | LPTA/BM/3 (as provided by the Board). | Shall be kept as long as license is valid.   | An inventory audit of all sealed sources should be carried out at appropriate intervals at least once a year.  |

|   |  |  |  |  |
|---|--|--|--|--|
|   | 6. Certificate for special form radioactive material.  | (As provided by the manufacturer).                       | Shall be kept for 2 years after the date of last possession      | Shall get the original copy from the manufacturer.   |
|   | 7. Isotope movement record (applicable for East Malaysia).   | (Appendix 1)<br>Note:<br>Import/Export and movement form | Shall be kept for at least 3 years after the date of last entry. | Within 7 days after the end every month, a completed form shall be submitted to the Board.   |
|   | 8. Records radiation leakage test of an exposure container.  | (Appendix 2).  | Shall be kept for at least 3 years after the date of last entry. | Should be carried out once in 7 days.  |
|   | 9. Leak test certificate of a sealed   | As provided by an approved lab.                          |  | For a new a source a leak test certificate shall be obtained from the manufacturer and shall be carried out at least once every 12 months.             |
| For each x-ray equipment                                  | 10. Return of possession of irradiating apparatus.   | LPTA/BM/3 (as provided by the Board).                    | Shall be kept as long as a licence is valid.                     | Shall include all tests specified by the manufacturer and the Board.   |
| Maintenance test records for gamma radiographic equipment | 11. Records of performance test by a manufacturer or an approved laboratory in accordance with the Malaysian standard or other standard recognized by the Board. |  | Shall be kept as long as a licence is valid.                     | Shall include all test specified by the manufacturer. Records these shall be kept, showing details of any defects and any action taken to remedy them. |

|  |  |  |  |  |
|--|--|--|--|--|
| Calibration record.  | 12. Records of the maintenance which have been carried out devices.  | As provided by a calibration centre recognized by the Board. | Shall be kept for at least 2 years after the date of last calibration. |  |
|  | Survey meter<br>13. Certificate of calibration.  |  |  |  |
| A record of area monitoring                                | 14. (i) <u>For fully enclosed site.</u><br><br>Record should be kept on result of initial area monitoring of the working area or if there is major modifications have been done. | Should use proper records.                                   | Shall be kept as long as the exposure room is still in service.        | Should include any significant events concerning radiation protection. |
|  | (ii) <u>For partly enclosed and open sites.</u><br><br>Record should be kept on results of area monitoring:<br><br>a. When starting work.  | Should use an area log-book.                                 | Should be kept for at least 2 years after the operation.               | Should include any significant events concerning radiation protection. |
|  | (iii) <u>For storage facility</u>  |  |  |  |
| Other records and reports which the Board deems necessary. | 15. Records and reports of an accident.  |  | Shall be kept as long as a is valid.                                   | Keep other records and reports as required by the Board time to time.  |

#### 6.3.2.1 Arrangement for the Services of an Approved Registered Medical Practitioner (ARMP).

The licensee shall arrange for the services of an ARMP who shall carry out medical surveillance of a worker [P.U.(A)61 Reg. 32(2)].

## **PART III**

# **RADIOGRAPHIC EQUIPMENT AND SAFETY DEVICES**

### *Chapter 3: Radiographic Equipment*

#### **10. General Requirements**

- 10.1 In all cases, the equipment chosen shall comply with the Malaysian standards or other standards which are recognized by the Board [P.U.(A)149 Reg. 12(b)].
- 10.2 No equipment shall be used for purposes other than those for which it has been designed. [P.U.(A)149 Reg. 2(b) and P.U.(A)61 Reg. 5]
- 10.3 All radiographic equipment shall be [P.U.(A)149 Reg.12(b)]:
  - a) Under continuous control of an RPO or a supervisor.
  - b) Maintained in good working condition.

Any defects in the smooth functioning of the equipment, however trivial, should be immediately attended to. Defective equipment, under no circumstances shall be put into operation [P.U.(A)149 Reg.12(b)].

#### **11. Apparatus for X Radiography**

##### **11.1 General Requirements**

- 11.1.1 With the exception in paragraph 11.1.2, every x-ray tube used for industrial radiography shall be enclosed in a housing such that the dose rate due to leakage radiation measured at a distance of 1 m from the anode does not exceed 10 mSv/h at every specified rating of that x-ray tube in that housing [P.U.(A)149 Reg.12(b)].
- 11.1.2 Exception from requirement in paragraph 11.1.1 is a permitted for "megavolt" x-ray equipment when used in a fully enclosed site. In such cases the dose rate due to leakage radiation, measured at a distance of 1 m from the anode shall not exceed 0.1 (10 %) of the dose rate in the useful beam at that distance [P.U.(A)149 Reg.12(b)].
- 11.1.3 The dose rate outside the auxiliary equipment, e.g. high tension generator, shall not exceed 0.2 mSv/h at 50 mm from the surface, or 0.02 mSv/h at any readily accessible place within the controlled area. If the transformer of valve enclosure is located outside the controlled area, these exposure should be reduced [P.U.(A)149 Reg.12(b)].

11.1.4 X-ray equipment shall be installed in such a manner that at commissioning, it can be demonstrated that the design emission characteristics are reproducible [P.U.(A)149Reg.12(b)].

11.1.5 Commissioning and test procedures for new x-ray systems shall be conducted according to the Malaysian Standards, or other standards recognized by the Board, to confirm that the system meets applicable performance requirements before they are put into use [P.U.(A)149Reg.12(b)].

## 11.2 Regular Inspection of the X-Ray Equipment

In carrying out any Regular inspection, reference should be made to the manufacturer's operating and maintenance manuals. The inspection include, but no limited to the following points [P.U.(A)149 Reg.12(b)]:

- a) All cables should be checked frequently for cuts or damages.
- b) All connections should be correctly and securely coupled.
- c) Protective caps on plugs and sockets should be replaced after use to prevent ingress of dust and moisture.
- d) Watertight connectors should be used correctly and securely coupled.
- e) Regular inspection shall be performed and recorded to verify that all warning signs remain in places and indicators are operating properly.

## 12. Apparatus for Gamma Radiography

### 12.1 General Requirements

12.1.1 Gamma-ray radiography shall be done by using an apparatus which complies with Malaysian standards or other standards recognized by the Board. Apparatus operated by removing the sealed source from the exposure container on a handling torch (e.g.: torch type exposure container) is PROHIBITED in Malaysia [P.U.(A)149 Reg.12(b)].

12.1.2 Apparatus for gamma radiography is classified according to the mobility of the exposure container [P.U.(A)149 Reg.12(b)]:

- a) Class P: a portable exposure container, designed to be carried by one man alone.
- b) Class M: a mobile but not portable exposure container, designed to be moved easily by suitable means provided for the purpose. (for example; Co-60)
- c) Class F: a fixed installed exposure container or one with mobility restricted to a particular working area.

12.1.3 The radiation leakage from an exposure container (when in the locked position and loaded with sealed sources of maximum activity) shall not exceed the dose rate limits shown in Table 7 [P.U.(A)149 Reg. 12(b)].

**Table 7: Maximum Radiation Leakage from an Exposure Container**

| Maximum Dose Rate (mSv/hr) |                                      |  |                                   |      |
|----------------------------|--------------------------------------|--|-----------------------------------|------|
| Class                      | On the external surface of container | 50 mm from the external surface of container | 1 m from the surface of container |      |
| P                          | 2                                    | or   | 0.5                               | 0.02 |
| M                          | 2                                    | or   | 1                                 | 0.05 |
| F                          | 2                                    | or   | 1                                 | 0.1  |

If radiation leakage exceeds the values shown in Table 7, the exposure container shall be withdrawn from use and arrangements shall be made immediately for its repair and if necessary, its decontamination [P.U.(A)149Reg.12(b)]

12.1.4 Table 8 summarizes the general design requirements for all exposure containers [P.U.(A)149 Reg.12(b)].

**Table 8: General Design Requirements for all Exposure Containers**

| Items      | Notes  |
|------------|--|
| Collimator | Means should be provided to collimate the radiation beam such that it shall be possible to put the device into the working position without bringing parts of the human body into the direct beam.   |
| Indicator  | <u>Indication of Sealed Source Position</u><br><br>Clear indication shall be given as to whether the sealed source is in the secured or exposed position.  |
|            | <u>Control mechanism</u><br><br>Control mechanism shall be clearly marked to indicate the direction of movement to move the source to the secured position and to move the source to the exposing position.  |
| Lock       | Shall be either of the safety type i.e. lockable without a key, or an integral lock from which the key cannot be withdrawn while an exposure container is in operation.<br><br>Shall retain the source in a secured position.<br><br>Shall not, if the lock is damaged, prevent the source when it is in the working position from being returned to its secured position. |



12.1.5 The surface of the source capsule, particularly the beam aperture, together with any other location likely to be contaminated in the event of a leakage, shall be tested, at least once every 12 months. Should the probable presence of free activity of more than 185 Bq be indicated, the source shall be considered as leaking [P.U.(A)149Reg.12(b)].

## 12.2 Maintenance of an Apparatus for Gamma Radiography

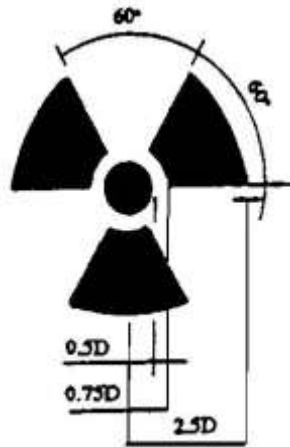
12.2.1 Annual maintenance shall only be undertaken by a recognized service provider by the Board.

In carrying out any maintenance, reference should be made to the manufacturer's operating and maintenance manuals [P.U.(A)149 Reg.12(b)]. Any such maintenance should follow good engineering practice and this includes [P.U.(A)149 Reg.12(b)]:

- a) An apparatus should be cleaned after use from any foreign matter such as mud and water.
- b) All screws, nuts or connections of an exposure container should be checked for tightness.
- c) Any moving part should be lubricated periodically with the correct lubricant.
- d) Confirmation that the source locking mechanism operates.
- e) Examination of the source assembly and cable connections cleanliness, wear of damage.
- f) Firm connections between the source assembly and cable; the cable sheath and container; and projection sheath and container.
- g) Examination of control cables and projection sheaths for kinks, tears, thread damage or other deficiencies.
- h) Checking the control cable movement through the control mechanism and, where the cable is detachable, protecting the exposed ends by means of a covering or a cap.

12.2.2 An exposure container shall be checked to ensure that it is permanently and indelibly marked by engraving, stamping or other means with the following [P.U.(A)149 Reg.12(b)].

a) The trefoil symbol (as in Figure 2).



Note: The following colours shall be used:

BLACK: for the design; and

YELLOW: for the background.

**Figure 2:** *Basic trefoil symbol with proportions based on a central circle of diameter  $D$ . The minimum size of  $D$  shall be 8mm [P.U.(A)61 Reg.24]*

- b) The word 'RADIOAKTIF' in letters not less than 10 mm in height.
- c) The maximum activity or authorized rating and specified radionuclides for the container.
- d) The manufacturer's type and serial number of the exposure container.
- e) The mass of the exposure container and details of any depleted uranium shielding incorporated.
- f) The radionuclide, activity, reference date and serial number of the sealed source contained.

### 13. Pipeline Crawler Equipment

- 13.1 All requirements for x-ray and apparatus for radiography (paragraphs 11 and 12) should also be applied to pipeline crawler equipment. The additional features as shown in Table 9 should also be taken into account, when using a pipeline equipment [P.U.(A)149 Reg.12(b)].

**Table 9:** *Additional Features for Pipeline Crawler Equipment*

| Items                 | Notes   |
|-----------------------|---|
| Warning               | <p>Suitable warning signals (e.g. automatic audible or Signals visible signals located in a box outside the pipe) capable of alerting persons in the vicinity of the crawler, whatever other distractions there might be, should be provided.</p> <p>It should be possible to differentiate between the pre-exposure warnings, (e.g. a steady signal for the first, and an interrupted signal for the second).</p>  |
| Other Design Features | <p>All associated sources should be provided with suitable storage containers.</p> <p>Except during an exposure, the sum of the dose rates from the exposure container (if any), the tell-tale sources and the control sources should not exceed 100 uSv/h on the accessible surface of the pipe under test.</p> <p>During temporary interruption of use, the apparatus should be cordoned and supervised to prevent access the sources.</p> <p>The control sequence designed so that unintended exposures are prevented.</p> |

- 13.2 During normal operation of pipeline crawler, when it is required to make a pipeline entry (e.g. to recover it), it is of the utmost importance to take the appropriate precautions to ensure that the radiation level and atmosphere inside the pipe are safe from toxic gases, welding or other toxic fumes. Alternatively, appropriate breathing apparatus shall be worn. For the latest safety requirements, refer to the relevant authorities.

#### *Chapter 4: Safety Devices*

### **14. General**

As a minimum, the following safety devices shall be made available during any radiographic operation [P.U. (A) 61 Reg. 50(1)]:

- a) Approved personnel monitoring devices.
- b) Survey meter.
- c) Warning signs.
- d) Notices.

## **15. Approved Personnel Monitoring Devices**

Approved personnel monitoring devices to be used during radiographic operations shall be TLD or film badge. However additional monitoring devices such as pocket dosimeter and audible alarm monitor may also be used [P.U.(A)61 Reg. 26(2)]. Methods on how to use approved personnel monitoring devices to monitor individual external exposures are shown in Table 10 [P.U.(A)61 Reg. 50].

## **16. Survey Meter**

16.1 Survey meter shall be calibrated [P.U.(A)149 Reg. 12(b)]:

- a) Before taking into use for the first time.
- b) Annually.
- c) After repair of any defects.

16.2 The meter shall be used to achieve the following minimum objectives [P.U.(A)61 Reg. 50(1)]:

- a) To monitor the dose rate at the barriers, that is to check that the barriers for the controlled area are positioned correctly.
- b) To check that an exposure container is in the secured position with the sealed source shielded after use.
- c) To help locate a jammed or lost source.
- d) To monitor working conditions.

16.3 Calibration of survey meter shall be done annually or after every repair by the calibration centre recognized by the Board [P.U.(A)61 Reg.50(2)]. The calibration record shall be kept by the licensee [P.U.(A)61 Reg. 55].

16.4 A survey meter in use shall carry a valid calibration sticker from the calibration centre recognized by the Board [P.U.(A)61 Reg. 50(1)].

16.5 Prior to every use, a check shall be made that; the meter detects the presence of radiation (e.g. by placing it near the surface of an exposure container in a closed condition) and should always make certain that the meter is set to the maximum range [P.U.(A)61Reg. 24 and P.U.(A)456 Reg. 25].

## **17. Warning Signs**

17.1 Warning sign bearing the trefoil symbol as in Figure 2 in paragraph 12.2.2 shall be used in the following instances [P.U.(A)61 Reg. 24 and P.U.(A)456 Reg. 25]:

- a) To label a source.
- b) To set up barriers for controlled areas, where it shall be posted clearly in strategic places.
- c) For a storage facility.
- d) For transportation of a package containing sealed source.

- 17.2 Warning sign shall incorporate a trefoil symbol as in Figure2 paragraph 12.2.2 and the words "BAHAN RADIOAKTIF" or "SINAR-X" or other appropriate descriptions to indicate the source [P.U.(A)61 Reg. 24].
- 17.3 The warning sign should preferably be fire resistant. Examples of the most widely used warning signs are shown in Figure 3.



Figure 3: Examples of Warning Signs.

Table 10: Monitoring individual radiation worker external exposure using approved personal monitoring devices

| <div> <div>Approved personnel monitoring devices</div> <div>Conditions</div> </div> | TLD   | Film Badge  | Pocket Dosimeter   | Audible alarm monitor  |
|---|---|---|--|--|
| Protection/safety of devices  | <p>Should be protected from:</p> <ol style="list-style-type: none"> <li>1. excessive heat</li> <li>2. moisture</li> <li>3. pressure</li> </ol> <p>Should be stored in a suitable low background area.</p> <p>Should not be carried home. Shall not be left at a place where radiation sources are likely to be present.</p> | <p>Should be protected from:</p> <ol style="list-style-type: none"> <li>1. excessive heat</li> <li>2. moisture</li> <li>3. pressure</li> </ol> <p>Should be stored in a suitable low background area.</p> <p>Should not be carried home. Shall not be left at a place where radiation sources are likely to be present.</p> | <p>Should be checked for good working order before use.</p> <p>Should be handled carefully.</p> <p>Should avoid mechanical damage, shock or entry of moisture.</p> | <p>Should avoid mechanical damage, shock or entry of moisture.</p> <p>Should be tested daily by holding it close to a source in its shielded position.</p> |
| Usage   | Mandatory, throughout radiographic operation.   | Mandatory, throughout radiographic operation.   | Optional, throughout radiographic operation.   | Optional as occasion demands such as at operation. (Note: Should respond to at least 7.5uSv/h.   |

|                                  |  |  |   |   |
|----------------------------------|--|--|---|---|
| Record                           | The TLD shall be sent for assessment to the approved laboratory every month and the results shall be kept.   | The film badge shall be sent for processing to the approved laboratory every month and the results shall be kept.<br><br>An individual film badge record is recommended (see Appendix 3) | Reading should be noted in a Register against the name of each worker before and after use. | Reading should be noted in a Register against the name of each worker before and after use. |
| If it is not returned            | Steps are to be taken by the RPO to obtain the TLD without delay.  | Steps are to be taken by the RPO to obtain the film badge without delay.   |   |   |
| Lost                             | A thorough investigation should be made.<br><br>If it is not recovered, shall be reported to the Board and that personnel involved shall be supplied with new TLD. | A thorough investigation should be made.<br><br>If it is not recovered, shall be reported to the Board and that personnel involved shall be supplied with new film badge.                |   |   |
| Damage or unintentional exposure | Shall immediately report to the RPO or the supervisor.<br><br>The RPO or the supervisor  | Shall immediately report to the RPO or the supervisor.<br><br>The RPO or the supervisor shall  |   |   |

|  |   |  |   |   |
|--|---|--|---|---|
|  | <p>shall immediately send the TLD to the approved laboratory for urgent processing.</p> <p>A new film badge should be provided to the affected person before he is redeployed for radiation work.</p> | <p>immediately send the film badge to the approved laboratory for urgent processing.</p> <p>A new film badge should be provided to the affected person before he is redeployed for radiation work.</p> |   |   |
| Suspected accidental exposure to the personnel | <p>His TLD shall be submitted for urgent assessment</p> <p>A new TLD should be provided to the affected person before he is redeployed for radiation work.</p>  | <p>His film badge shall be submitted for urgent assessment</p> <p>A new film badge should be provided to the affected person before he is redeployed for radiation work.</p>                           | The dose should be recorded and documented. | The dose should be recorded and documented. |




## 18. Notices

- 18.1 The notices shall be in Bahasa Malaysia and in other languages if necessary [P.U.(A)61 Reg. 24(1)]. As a minimum, notices shall include words such as “AWAS”, “BAHAYA” or equivalent [P.U.(A)61 Reg. 24].
- 18.2 The name, address and telephone number of the RPO responsible for the site, shall be displayed on each notice [P.U.(A)61 Reg. 24].
- 18.3 The notices should be fire resistant and have durable black lettering embossed or stamped on a white background [P.U.(A)61 Reg. 24(2)]. Typical examples are shown in Figure 4.

|   |   |
|---|---|
| <b>AWAS</b><br><b>ALAT PENGAWASAN SINARAN</b><br><b>DIPERLUKAN MELEBIHI</b><br><b>HAD INI</b> | <b>AWAS</b><br><b>PARAS SINARAN TINGGI</b><br><b>KAWASAN BAHAN</b><br><b>RADIOAKTIF</b> |
| <b>CAUTION</b>  | <b>CAUTION</b>  |
| Radiation monitoring devices<br>needed beyond this limit                                      | High radiation level Area of<br>radioactive material                                    |
| Nama Pegawai<br>perlindungan sinaran:   | Nama Pegawai<br>perlindungan sinaran  |
| Alamat :  | Alamat :  |
| No. Telefon :   | No. Telefon :   |

Figure 4 : An example of notice

- 18.4 Notices may be incorporated with warning signs as shown in Figure 5 [P.U.(A)61 Reg. 24(2)]

|  |   |
|--|---|
| <b>BAHAYA</b><br><b>JANGAN MASUK</b><br>Danger<br>No entry<br><br><b>BAHAN</b><br><b>RADIOAKTIF</b> | Nama Pegawai<br>perlindungan sinaran :<br>Alamat :<br>No. Telefon : |
|--|---|

Yellow background →

← White background

Figure 5: An example of a Notice with Warning Sign Incorporated.

**PART IV**  
**NORMAL WORKING PROCEDURE**

*Chapter 5: Planning A Working Procedure*

**19. General**

When planning a working procedure, the main objective shall be TO MINIMIZE radiation exposure to workers and members of the public [P.U (A) 61 Reg. 5].

At least two workers should be employed for every job site, that is an operator and an RPO or a supervisor [P.U. (A) 61Reg. 23(6)].

Radiography works should not be carried out in public area. However, if radiography work has to be carried out in public area, the licensee shall obtain written approval from the Board as required in the conditions of licence. In this case, either RPO or supervisor shall be present at the site.

Radiography work procedures in public area, as well as transportation and storage requirements are the as specified in this Code of Practice.

**20. Radiographic Sites**

Industrial radiography shall be carried out at one of the following radiographic sites [P.U.(A)61 Reg. 24(1)]:

- a) Fully enclosed site.
- b) Partly enclosed site.
- c) Open site.

Where reasonably practicable the industrial radiography should be carried out in a fully enclosed site [P.U.(A)61 Reg.5]. The requirements for radiographic sites are shown in Table 5 in paragraph 6.3.1.6 [P.U (A) 61 Reg. 24].

**21. Prior to Radiographic Operation**

The following factors shall be taken into account when planning a working procedure prior to radiographic operation [P.U.(A)61 Reg. 5]:

- 21.1 Permission to work: Shall be obtained from person responsible for the site.
- 21.2 Radiographic site: The areas should not be occupied by members of public. Members of public shall be excluded from the controlled area prior to radiographic operation.
- 21.3 Radiographic technique: Should be that which involves least exposures consistent with the needs of a good radiograph.

- 21.4 Radiographic parameters: Should be consistent with good technique and practice using appropriate film, penetrameter, screen, suitable exposure time, etc.
- 21.5 Radiographic and non-radiographic works: Should be segregated whenever practicable.
- 21.6 Collimator and local shielding: Should be made available and used whenever possible.
- 21.7 General Safety Equipment
- a) Approved personnel monitoring device: Shall be available to all workers involved. Radiographic operation shall not proceed without this equipment.
  - b) Survey meter: Shall have a valid calibration sticker. Radiographic operation shall not proceed if the survey meter is not available; is not in good working order, or is damaged.
  - c) Warning devices: Should be provided in the form of lamps or audible signals or both.
  - d) Warning signs and notices: Shall be used to identify and define a controlled area.
- 21.8 A storage facility: Shall be provided to the standards described in Chapter 7 (Paragraph 26)
- 21.9 Source activity or output of x-ray equipment: Should be selected to give reasonable exposure times whilst minimizing the dose to workers. The work should be organized to comply with the ALARA principle. If the dose rate is expected to exceed this criterion, one or more of the following courses of action should be taken:
- a) Collimator should be used when practicable.
  - b) Use the accessories which provide more shielding for the worker.
  - c) Use a source with lower activity or reduce the power of x-ray equipment.
  - d) Reduce the time for exposure, for example by:
    - i). Using “fast” film.
    - ii). Reducing source to film distance.
    - iii). Reducing the workload individual worker by distributing the work evenly among other workers.
- 21.9.1 Allowable working time: Should be calculated by measuring the dose rate and substituting it in the following equation:

$$\text{Allowable working time (h/year)} = \frac{\text{operational limit mSv / year}}{\text{dose rate mSv / h}}$$

Example 1 :How many hours could an operator spend each month in an area, in which the dose rate is 0.05 mSv/h with an operational limit of 18 mSv/h year?

Solution :

$$\begin{aligned}\text{Allowable working time} &= \frac{\text{operational limit mSv / year}}{\text{dose rate mSv / h}} \\ &= \frac{18 \text{ mSv / year}}{0.05 \text{ mSv / h}} \\ &= 360 \text{ h/year}\end{aligned}$$

Therefore, the allowable time is 360 h/year.

If the allowable working time (hours in a week is required, a proper calculation must be made, but it shall not correspond to a figure exceeding 18 mSv/year.

21.9.2 The position of control panel (in the case of x-ray) or winding cable (in the case of gamma ray) shall be carefully chosen. If possible it should be outside the controlled area. If this is not possible, the distance from the control point panel/winding cable to the radiation source shall be maximized by straightening control panel/winding cable and the guide tube. The control panel/winding cable should be placed behind any convenient shielding which will provide further protection. The worker should not remain inside the controlled area during the exposure. The route taken to and from the control panel/winding cable should not cross the useful beam.

21.10 Barriers for controlled areas: Shall be established before starting radiographic operation and NOT during the operation, when there may already be people in the areas. A preliminary estimate of distance from the working position to the barrier position can be made using one of the following methods [P.U.(A)61 Reg. 24 (2)]:

21.10.1 Using a Graph

The maximum distance from the working position to the barrier can be estimated by using a graph. An example of a graph indicating barrier distances of Ir-192 and Co-60 is shown in Figure 6.

21.10.2 Using the Inverse Square Law

The maximum distance from the working position to the barrier can be calculated using inverse square law which is expressed as:

$$\frac{I_1}{I_2} = \frac{(d_2)^2}{(d_1)^2} ; \text{ where}$$

$d_1$  and  $d_2$  are the distances

$I_1$  dan  $I_2$  are the dose rates at distances  $d_1$  dan  $d_2$

respectively from the source.

Example 2: The dose rate at 1m from a particular sealed source is 0.2 mSv/h. At what distance will it be a dose rate of 7.5  $\mu$ Sv/h?

Solution :

$$\frac{I_1}{I_2} = \frac{(d_2)^2}{(d_1)^2}$$

$$\frac{(d_2)^2}{(1\text{m})^2} = \frac{0.2 \text{ mSv/h}}{7.5 \text{ uSv/h}}$$

$$\frac{(d_2)^2}{\phantom{d_2}} = \frac{0.2 \text{ mSv/h} \times (1\text{m})^2}{0.0075 \text{ mSv/h}}$$

$$d_2 = 5.16 \text{ m}$$

Therefore, a dose rate of 7.5 uSv/h will be at a distance of 5.16 m.

### 21.10.3 Using Dose Rate Constant

21.10.3.1 To calculate barrier distances from a sealed source, the dose rate constant “k-factor” can be used by using the following mathematical expression:

$$I/d^2 = kA \quad ; \quad \text{where}$$

I is the dose rate (mSv/h)

k is the dose rate constant (mSv/h/GBq) at a distance of 1 m from the source (see Table 11).

A is the activity (GBq)

d is the distance (m)

Example 3: What is the dose rate from at 1GBq Co-60 source at 2 m?

Solution :

1 GBq of Co-60 gives a dose rate of 0.306 mSv/h at 1m. If the dose rate at 2 m = I<sub>2</sub>, then by inverse square law:

$$I_1 (d_1)^2 = I_2 (d_2)^2$$

$$I_2 \times 2^2 = 0.306 \times 1^2$$

$$I_2 = \frac{0.306 \text{ mSv/h}}{4}$$

$$= 0.0765 \text{ mSv/h}$$

Therefore, the dose rate at 2 m is 76.5 uSv/h.

21.10.3.2 The above method can also be applied for x-rays by replacing "activity (GBq)" with "tube current – (mA-min)" (see, Table 12).

**Table 11 :** The dose rate constant (k-factor) of common sealed sources

| Sealed Sources | k (mSv/h/GBq at 1 m) |
|----------------|----------------------|
| Co-60          | 0.345                |
| Cs-137         | 0.078                |
| Ir-192         | 0.125                |

**Table 12 :** Example of dose rate constant for various kilovoltages after passing through a copper filter.

| Tube Voltage (kV) | “k – Factor”<br>(mSv/mA.min at 1 m) |            |           |
|-------------------|-------------------------------------|------------|-----------|
|                   | 0.07 mm Cu                          | 0.10 mm Cu | 0.5 mm Cu |
| 50                | 3.2                                 | 1.8        | -         |
| 75                | 7.0                                 | 5.0        | 0.5       |
| 100               | 12.0                                | 8.5        | 1.6       |
| 150               | 23.0                                | 17.5       | 6.0       |
| 200               | 36.0                                | 29.0       | 12.5      |
| 250               |                                     |            | 19.0      |
| 300               |                                     |            | 28.0      |
| 400               |                                     |            | 56.0      |
| 500               |                                     |            | 80.0      |
| 1000              |                                     |            | 330.0     |

Example 4 : What is the dose rate at 5m from an x-ray machine operated at the following conditions: tube Voltage :150 kV; tube current (A) : 10 mA; filter : 0.1mm Cu?

Solution :

$$\begin{aligned}
 I &= \frac{(k) A}{d^2} \\
 &= \frac{17.5 \times 10}{5^2} \text{ mSv/min} \\
 &= \frac{17.5 \times 600}{25} \text{ mSv/h} \\
 &= 420 \text{ mSv/h}
 \end{aligned}$$

Therefore, dose rate at 5 m in is 420 mSv/h

## 21.11 Provision of Shielding

Dense materials such as lead, concrete or iron should be used as shielding materials for x and gamma rays. The thickness of a required shielding material can be calculated by:

### 21.11.1 Using Half-Value Layers (HVL) or Tenth-Value Layers (TVL) :

The thickness of a required shielding material can be calculated by using the using the so-called HVL and TVL which are mathematically expressed as:

$$\begin{aligned} I &= I_0/2^n \quad (\text{for HVL}) ; \text{ and} \\ I &= I_0/10^n \quad (\text{for TVL}) ; \text{ where} \end{aligned}$$

$n$  is the number HVL or TVL required respectively.

$I_0$  is the initial dose rate.

$I$  is the dose rate after penetrating a  $n$  HVL or  $n$  TVL thickness of the materials

The approximate values of TVL and HVL for various materials for different sources are shown in Table 13.

Example 5: A 200 x-ray equipment is operating at 10 by using 0.5 mm Copper filter. Calculate the thickness of concrete wall required to reduce the dose rate at 1 m to a limit of 2.5 uSv/h.

Solution :

k-factor with 0.5 mm Copper = 12.5 mSv/mA - min (from Table 12)

$$\begin{aligned} \text{Number of HVL's required} &= 2^n = I_0 \\ I & \end{aligned}$$

$$\begin{aligned} &= \frac{12.5 \times 600}{2.5 \times 10^{-3}} \end{aligned}$$

$$2^n = 300 \times 10^4$$

$$n = 22$$

From Table 13, HVL of concrete at 200 kVp = 26 mm; so 26 mm x 22 = 572 mm thick of concrete is required as a barrier

**Table 13:** Approximate value of TVL and HVL for various materials for different sources (Thickness in mm).

| Sources | Lead     |         | Steel   |         | Concrete |        |
|---------|----------|---------|---------|---------|----------|--------|
|         | TVL (mm) | HVL(mm) | TVL(mm) | HVL(mm) | TVL(mm)  | HV(mm) |
| x-rays  |          |         |         |         |          |        |
| 50 kVp  | 0.25     | 0.07    | 1.5     | 0.5     | 14       | 9      |
| 100 kVp | 1.0      | 0.3     | 5.5     | 2       | 54       | 17     |
| 150 kVp | 1.0      | 0.3     | 13      | 4       | 70       | 22     |
| 200 kVp | 1.4      | 0.45    | 19      | 6       | 86       | 26     |
| 250 kVp | 3.2      | 1.0     | 36      | 12      | 90       | 28     |
| 300 kVp | 4.9      | 1.5     | 45      | 15      | 102      | 30     |
| Co-60   | 41.2     | 12.4    | 73.7    | 22.1    | 218.4    | 66     |
| Ir-192  | 16.3     | 4.8     | 50.8    | 15.5    | 157.5    | 48.3   |

#### 21.11.2 Using a Transmission Factor

The thickness of shielding material can also be calculated by using the following mathematical expression :

$$I = \frac{AkT}{d^2} ; \text{ where}$$

I is the dose rate mSv/h

A is the activity of the sources (GBq)

k is the dose rate constant (mSv/h/GBq) at a distance of 1 m

T is the transmission factor which may be defined as the ratio of the dose rate with and without barriers.

d is the distance (m)

Graphs showing the thickness factor, T, for x and gamma rays by various thickness of common shielding materials are shown in Figures 7, 8, 9, 10, 11, 12, 13 and 14.

Example 6: What thickness of concrete is required to reduce the radiation from a 1 TBq Ir-192 sources to an acceptable level for members of the public who are working at a distance of 4 m from this sources? Total weekly exposure time is 10 hours



Solution : Dose limit for the public is 400  $\mu\text{Sv}$  a month, equivalent to 100  $\mu\text{Sv}$  a week. Maximum dose rate is therefore  $100/10 \mu\text{Sv/h} = 10 \mu\text{Sv/h}$ .

$$I = \frac{A k T}{d^2}$$

$$10 \mu\text{Sv/h} = 0.01 \text{ mSv/h} = \frac{1000 \text{ GBq} \times 0.113 \text{ mSv/h/GBq} \times T}{4^2}$$

$$T = \frac{0.01 \times 16}{1000 \times 0.113}$$

$$= 0.00142$$

From Figure 13; the transmission factor of 0.00142 corresponds to 43 cm of concrete. So the thickness of concrete required is 43 cm.

## 22. During Radiographic Operation

The following factors shall be considered during radiographic operation [P.U. (A) 61 Reg. 24]:

- 22.1 RPO/RPS/Operator/trainee operator shall ensure safety of workers and to avoid unauthorized usage of radiographic equipment and to ensure compliance with legislation.
- 22.2 RPO/RPS/Operator/trainee operator shall be constantly alert and stay in positions where they can ensure the effectiveness of the barrier. Should the barrier breaks for any reasons or any member of the public enters the controlled area, the source shall be returned immediately to its shielded position or the X-ray equipment be switched off.

## 23. After Radiographic Operation

The RPO/RPS/Operator/trainee operator shall ensure that all radiographic equipment including the source, warning sign and notices have been removed from the site. A final area monitoring shall be made before the site is vacated on completion of work. He should then inform the person responsible for the site, when this has been completed [P.U.(A)61 Reg. 25].

### *Chapter 6 : Planned Special Exposure*

## 24. General Requirements

- 24.1 Any proposed planned special exposure shall not be carried out except with prior approval in writing from the Board [P.U.(A)61 Reg.10(1)].
- 24.2 The procedures which are intended under a planned special exposure shall minimize exposure to workers. The dose limit for a planned special exposure as shown in Table 1 in paragraph 6.2 shall not be exceeded [P.U.(A)61 Reg. 10(4)].
- 24.3 Only workers who are volunteers may participate in the planned special exposure. Before accepting volunteers, the following shall be taken into account [P.U.(A)61 Reg. 10 (3)].

- a) Previous experience
- b) State of health
- c) Special skill
- d) Social and economic responsibilities

24.4 The licensee shall not permit a worker to participate in the planned special exposure [P.U.(A)61 Reg. 10(5)];

- a) If, during the previous 12 months, the worker has received an exposure giving rise to a dose in excess of the ADLs laid down in Table 1 in paragraph 6.2.
- b) If the worker has previously received accidental or abnormal exposures giving rise to doses, the sum of which exceeds five times the ADLs laid down in Table 1 in paragraph 6.2.
- c) If the worker is a female of reproductive capacity.

24.5 Before carrying out a duty under a planned special exposure, the worker shall be thoroughly informed about the potential risks involved and fully instructed in the measures to be taken to keep the exposures as low as is reasonably achievable [P.U.(A)61 Reg. 10(6)].

24.6 After a planned special exposure is completed, the dose received shall be reported to the worker concerned, the ARMP and to the Board, not later than 2 weeks after the results are available [P.U.(A)61 Reg. 10(8)].

## **25. Storage of Apparatus for X radiography**

With X-ray equipment, no special storage facility is required other than protection against theft, vandalism or unauthorized usage. A small lockable storeroom or cupboard will suffice. Keys to the X-ray control panel and storeroom should be kept by the Operator or RPO or supervisor [P.U.(A) 61 Reg. 52].

## **26. Storage of a sealed source**

26.1 General

26.1.1 When not in use, exposure containers shall be stored in a facility such as a storage pit, a storage room or a storage enclosure [P.U.(A)61 Reg. 52 & P.U.(A)149 Reg. 12(b)].

26.1.2 Prior approval for the proposed design and siting of a storage facility shall be obtained from the Board before it is put into use [P.U.(A)149 Reg. 12(b)].

26.1.3 In selecting a location for a storage facility, the licensee shall take into account the presence of any hazard including risks due to fire and flood. Radioactive sources should be separated from other hazardous substances such as combustible, corrosive and explosive materials [P.U.(A)149 Reg. 12(b)].

- 26.1.4 The storage facility should be at a place that will avoid the need to transport a package containing a sealed source, over great distances [P.U.(A) 149 Reg. 12(b)].
- 26.1.5 The storage facility shall be made from materials with a minimum of one-hour fire resistant and should be located in a suitable isolated area of minimum occupancy [P.U.(A) 149 Reg. 12(b)].
- 26.1.6 Other equipment such as notices, barrier equipment and radiographic equipment should not be kept in the same store as the sealed source.
- 26.2 Storage Pit
- 26.2.1 A storage pit can be constructed to provide a storage facility either at company's premises or remote locations where the requirement may be temporary. The pit (refer Figure 15) should be prepared before the sealed source is brought to the site [P.U.(A)61 Reg. 52 & P.U.(A)149 Reg. 12(b)].
- 26.2.2 The dose rate at the fence shall be less than 2.5 uSv/h and the dose rate in areas accessible to members of public shall not exceed 1 mSv/y [P.U.(A)61 Regs. 8, 9, 11 & 12].
- 26.2.3 It is suggested that the storage pit be constructed as follows [P.U.(A)149 Reg. 12(b)]:
- A vertical steel tube 0.5 m to 1m diameter and about 1m to 2 m long with a welded base sunk into the ground with just sufficient protrusion.
  - Should be fitted with a "coat-hanger" hook-type bracket inside the tube next to the top.
  - The whole assembly should be waterproofed. Care should be taken to avoid water seepage into the pit which should be duly protected.
  - The pit shall be enclosed at a distance of at least 1.6 m by a fence with 2 lockable gate and the keys for the gate and storage pit shall be kept by the RPO or the supervisor.



Figure 15: An example of a storage pit.

- 26.2.4 Embossed type warning signs and notices shall be clearly posted on the lid of the storage pit and on the 4 walls of the fence (refer Figure 5 in paragraph 18.4) [P.U.(A)61 Reg. 24].
- 26.3 Storage Room
- 26.3.1 The licensee should store exposure containers in a storage room [P.U.(A)61 Reg. 52 & P.U.(A)149 Reg. 12(b)].
- 26.3.2 The storage room should be provided with adequate illumination and ventilation. Provision should be made to switch off all the electrical services from the outside of the storage room [P.U.(A)149 Reg.12(b)].
- 26.3.3 The dose rates outside the adjoining walls of the storage room shall not exceed 2.5 uSv/h provided that the dose received by members of the public shall not exceed 1 mSv/y [P.U.(A)61 Regs. 8, 9, 11 & 12].
- 26.3.4 The storage room shall be lockable and access to the room shall be restricted. The key of the storage room shall be kept by the Operator or RPO or the supervisor [P.U. (A) 149 Reg. 12(a) and P.U.(A)61 Reg. 24].
- 26.3.5 Warning signs and notice shall be clearly posted at 4 walls as well as at the entrance of the storage room (refer Figure 5 in paragraph 18.4) [P.U.(A)61 Reg. 24].
- 26.4 Storage Enclosure
- 26.4.1 The use of storage enclosure is allowed only where the construction of storage room or storage pit is not possible (e.g.: at barges or offshore) [P.U.(A)149 Reg. 12(b)].
- 26.4.2 The boundary of storage enclosure shall be formed by a physical barrier to prevent access [P.U.(A)61 Reg. 24].
- 26.4.3 The dose rate at accessible places outside a physical barrier shall not exceed 2.5 uSv/h provided that dose received by members of the public shall not exceed 1 mSv/y [P.U.(A)61 Regs. 8, 9, 11 & 12].
- 26.4.4 Warning signs and notices shall be conspicuously posted in strategic places (refer Figure 5 in paragraph 18.4) [P.U.(A)61 Reg. 24].
- 26.4.5 The storage enclosure shall be under the supervision of the Operator or RPO or the supervisor [P.U.(A)149 Reg. 12(b) and P.U.(A)61 Reg. 24].
- 26.5 Temporary Storage Vehicle
- 26.5.1 Under a special condition, exposure container may be stored temporarily in a vehicle with prior approval in writing from the Board.
- 26.5.2 Vehicle used for this purpose shall not be parked in public area.

**27. General Procedures**

- 27.1 Source changing shall be performed only with the use of an appropriate source changer and by a person specifically trained and authorized to do so. Any licensee who wants to do source changing on his own shall get prior approval from the Board [P.U.(A)149 Reg. 12(a)] and P.U.(A)61 Reg. 24].
- 27.2 The precautions for radiographic operations shall also be applied when changing a source. These include [P.U.(A)61 Reg. 5]:
- a) Making sure prior to the operation, that approved personnel monitoring devices and all necessary equipment, including any special tool and shielding materials are available.
  - b) Obtaining and following source changing manuals from the manufacturer. The manuals should include a complete diagram of the device.
  - c) Establishing of a controlled area.
  - d) The operations should be carried out at a flat, hard and dry surface.
  - e) When the new (replacement) source has been transferred to the exposure container, make survey by using a survey meter to ensure that both sources have been returned to their shielded positions. Radiation leakage shall not exceed any of the leakage limits as specified in Table 7 in paragraph 12.1.3. Transport label outside the container has to be changed to indicate the new sources.
  - f) Lock both the exposure container and source changer.
  - g) Return both the exposure container and source changer to a storage facility.

**PART V**  
**TRANSPORTATION OF A PACKAGE CONTAINING SEALED**  
**SOURCE**

**28. General Procedures**

- 28.1 Transportation of a package containing sealed source shall be carried out in accordance with the Radiation Protection (Transport) Regulation 1989 P.U.(A)456 Reg. 3].
- 28.2 In formulating the procedures for the transportation of a package containing sealed source, the licensee shall also take into account, the involvement of a person who has very little understanding in radiation protection [P.U.(A)61 Regs. 4 & 5].
- 28.3 Within 7 days after the end of every month, the licensee shall complete and submit to the Board, the isotope movement record (see Appendix 1) for the previous movements of a package containing sealed source [P.U.(A)61 Reg. 55].

*Chapter 9: Packaging*

**29. General**

- 29.1 The exposure container supplied by the manufacturer shall not be used to contain other type of sealed source or with the same type of sealed source with higher activity, other than for which it is intended, except with prior approval from the Board [P.U.(A)456 Regs. 18 & 30].
- 29.2 The licensee wishing to design his on package shall have it certified by the Board before it is put into use [P.U.(A)456 Regs. 20, 71 & 75].

**30. Receiving Package Containing Sealed Source**

- 30.1 A consignee of a package containing sealed source shall make arrangements to receive it when it is delivered [P.U.(A)61 Reg. 5].
- 30.2 The consignee shall, as soon as practicable on receive of a consignment and before opening it, examine the package containing sealed source for any defects or leakage of its radioactive content. The licensee shall survey it with a survey meter as soon as possible. Radiation leakage shall not exceed any of the leakage limits specified in Table 7 in paragraph 12.1.3. If the radiation leakage exceeds any of the leakage limits, it shall be secured, a controlled area shall be established and appropriate actions shall be taken to rectify the situations [P.U.(A)456 Reg. 70].

30.3 If the package containing sealed source has or appears to have defects or its radioactive content is found or appears to be leaking, the consignee shall [P.U.(A)456 Reg. 70]:

- a) Measure the radiation level at 1 m from the external surface of it and on its surface.
- b) Measure the contamination level on the external surface of it.

30.4 The consignee shall report the result of the measurement carried out (using LPTA/BM/3 form) to the Board [P.U.(A)61 Reg. 55]:

- a) Within five working days, if the radiation level exceeds the prescribed limits.
- b) Immediately, notwithstanding sub-paragraph (a), if the radiation level exceeds 10 mSv/h and 2 mSv/h, respectively on and at 1 m from the external surface, of the package containing sealed source.

30.5 The consignee shall retain records of all observations in the LPTA/BM/3 form for a period of at least two years and if requested to do so, provide the Board with full access to such records [P.U.(A)61 Reg. 55].

### **31. Labeling of a Package Containing Sealed Source**

31.1 When the package containing sealed source is to be transported, additional labeling as shown in Table 14 other than the labels permanently fixed to the package containing sealed source should be provided [P.U.(A)456 Regs. 25, 26, 27 & 29].

31.2 The additional label should include:

- a) The radioactive contents e.g. Ir-192.
- b) The maximum activity of radioactive material in Becquerel (Bq) at the time of transport.
- c) The transport index.

### **32. Requirements for Import/Export of Radiographic Equipment**

32.1 The licensee shall obtain import/export authorization from the Board (Appendixes 4 & 5) prior to the import or export of radiographic equipment [P.U.(A)61 Reg. 55 and P.U.(A)149 Reg.12(b)].



32.2 This authorization will be issued subject to submission of the following documents [P.U.(A)149 Reg. 12(b) and P.U.(A)61 Reg. 55]:

- a) Approval certificate for the design of a type B package.
- b) Approval certificate for the design of a special form radioactive material.


32.3 When the activity or import/export of radiographic equipment has been completed, the licensee has to send all the following documents to the Board [P.U.(A)61 Reg. 55] :

- a) Shipper's declaration for dangerous goods.
- b) Custom's clearance documents.
- c) Department of civil aviation approval permit for the transportation of the dangerous goods by air.
- d) Other documents required by the Board.

**Table14:** *Transport Labels [P.U.(A)456 Regs. 27 (1) and (29) ]*

| Label  | Transport conditions (dose rate)   |
|--|--|
| <p><b>CATEGORY I- WHITE</b></p>  <p>The background colour of shall be white, the colour of the trefoil and the printing shall be black and the colour of the bars shall be red.</p>  | <p>at surface : <math>\leq 0.005</math> mSv/h</p> <p>at 1 m : 0 mSv/h</p> <p>Transport index : 0</p>               |
| <p><b>CATEGORY II –YELLOW</b></p>  <p>The background colour of the upper half of the label shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black and the colour of the category bars shall be red.</p> | <p>at surface : <math>\leq 0.5</math> mSv/h</p> <p>at 1 m : 0 mSv/h</p> <p>Transport index : does not exceed 1</p> |



|   |  |
|---|--|
| <p style="text-align: center;"><b>CATEGORY III –YELLOW</b></p>  <p>The background colour of the upper half of the label shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black and the colour of the category bars shall be red.</p> | <p>under normal condition :</p> <p>at surface : <math>\leq 2</math> mSv/h</p> <p>at 1 m : <math>\leq 0.1</math> mSv/h</p> <p>Transport index : does not exceed 10</p> <p>under exclusive use :</p> <p>at surface : <math>\leq 10</math> mSv/h</p> <p>at 1 m : <math>\leq 10</math> mSv/h</p> <p>Transport index : No limit</p> |
|---|--|

*Chapter 10: Requirements For Transportation of a Package Containing Sealed Source*

**33. General**

- 33.1 The package containing sealed source having activities of 27 Curie (1 TBq) in the case of Ir-192 or 11Ci (0.4 TBq) in the case of Co-60 or more should be properly packed in a transit box (that comply USNRC) and placed in a compartment of a vehicle and it shall be securely locked. The key should be available with an Operator or RPO or a supervisor. The consignment shall be firmly secured to prevent any movement during transport [P.U.(A)61 Reg. 5].
- 33.2 The package containing sealed source having an activity less than 27 Curie (1 TBq) in the case of Ir-192 or 11 Ci (0.4 TBq) in the case of Co-60 need not to be packed in a transit box (that comply USNRC). The package shall be placed in a compartment of a vehicle.
- 33.3 A package containing sealed source which does not satisfy all the applicable requirements of the Radiation Protection (Transport) Regulation 1989 shall be transported only by a special arrangement [P.U.(A) 456 Reg. 35].
- 33.4 A package containing sealed source shall be segregated from places occupied by the transport workers and the members of the public and any exposures to them shall not exceed 5 mSv/y respectively [P.U.(A)456 Reg. 35].
- 33.5 A package containing sealed source shall be segregated from radiographic films or other photographic films and any exposure to such film shall not exceed 0.1 mSv per consignment of the films [P.U.(A)456 Reg. 69(3)].

- 33.6 A package containing sealed source shall be segregated from other dangerous good [P.U.(A)456 Reg. 69(4)].

#### **34. Transportation of a Package Containing Sealed Source by Road**

- 34.1 All related requirement and accessories required for the safe handling of an exposure container such as [P.U.(A)61 Reg. 5]:

- a) Survey meter.
- b) Rope complete with pennants.
- c) Warning sign board e.g. “BAHAYA – KAWASAN SINARAN”.
- d) 4 stanchions for supporting barrier line.

should also be transported together with the exposure container. In this case, the use of transport checklist as in Appendix 6 is recommended.

#### **34.2 Under Exclusive Use**

- a) When the vehicle is under exclusive use for transporting a package containing sealed source, the radiation level at any normally occupied positions shall not exceed 0.02 mSv/h. The radiation level on the outside walls of the vehicle and at 2 m from it shall not exceed 2mSv/h and 0.1mSv/h, respectively [P.U.(A)456 Reg. 58(1)].
- b) The route used shall be planned in such a way that the time taken for the transportation is minimized [P.U.(A)61 Reg. 5].
- c) The road vehicle carrying a package containing sealed source shall display placards as shown in Figure 16, on each external lateral side on the rear of the vehicle.

In the case of a vehicle, the placards shall be displayed on the two lateral external sides [P.U.(A)456 Reg. 66].

For road vehicle without sides, the placard shall affixed directly on the package, provided that the placards are readily visible [P.U.(A)456 Reg. 66(22)].

- d) Placards affixed to the vehicle shall be removed when no package containing sealed source is being transported [P.U.(A)456 Reg. 50].
- e) At no time shall passengers other than an assistant driver be carried in the same vehicle transporting a package containing sealed source. The RPO or the supervisor shall be in constant attendance during any movements of the package containing sealed source [P.U.(A) 149 Reg. 12(1) and P.U.(A)456 Reg. 63].
- f) The approved personnel monitoring devices shall be provided to the driver and his assistant before transporting a package containing sealed source [P.U.(A)456 Reg. 69(2)].

- g) A vehicle containing a package which contain sealed source other than white label packages should not be parked for more than an hour unless there is a clear space of at least 2 m all round the vehicle when it is parked [P.U.(A)61 Reg. 5].
- h) A vehicle containing a package which contain sealed source should not be left unattended in any public place [P.U.(A)61 Reg. 5].
- i) The consignor shall make out and sign a transport document (Appendix 7), for each consignment of a package containing sealed source, and shall be attached to the container when offered for transport. A copy of this transport document shall also be displayed conspicuously in the driver's compartment [P.U.(A)456 Regs. 48 & 49].

**Figure 16 : Placard**



\* Note: Minimum dimensions are given; when larger dimensions are used, the relative proportions must be maintained. The figure “7” shall not be less than 25mm high. The background colour of the upper and lower halves shall be yellow and white, respectively. The colour of the trefoil and the printing shall be black [P.U.(A)456 Reg. 29]

#### 34.4 Under Non-Exclusive Use

The licensee shall get prior approval from the Board for transportation of a package containing sealed source under non- exclusive use [P.U.(A) 61 Reg. 55].

**35.       Transportation of a Package Containing Sealed Source by Sea Inland Waterway Vessel**

In addition to the Radiation Protection (Transport) Regulations 1989, the requirements of the latest addition of IMDG-Code shall also be complied with, when transporting a package containing sealed source by sea or inland waterway vessel [P.U.(A)456 Reg. 3(3)].

**36.       Transportation of a Package Containing Sealed Source by Air**

In addition to the Radiation Protection (Transport) Regulations 1989, the requirement of the latest edition of the “ICAO and IATA – Dangerous Goods Regulations” shall also be followed transporting a package containing sealed source by air [P.U.(A)456 Reg. 3(3)].

**PART VI  
PROCEDURES UNDER ABNORMAL  
SITUATIONS**

**37. Reporting**

Upon discovery any abnormal situations shall be reported to the :

Atomic Energy Licensing Board,  
Ministry of Science, Technology and Innovation,  
Batu 24, Jalan Dengkil,  
43800 Dengkil,  
Selangor Darul Ehsan

Tel : 03-8922 5888  
Faks : 03-8922 3685

Within 24 hours after the incident happened. The licensee shall submit to the Board a detailed written report of the abnormal situations within 30 days after such incident [P.U.(A)61 Regs. 31, 53(1) and 55(1)].

**38. Equipment To Be Used Under Abnormal Situations**

Suitable equipment to used under abnormal situations shall be kept at each radiographic site or at a location within easy reach of a radiographic site, which should include [P.U.(A) 149 Reg. 12(b)]:

- a) Rope
- b) Handlamp
- c) Bags of lead shot, at least two bags of 2 kg each.
- d) Lead pot
- e) Cutter
- f) Handling tongs, at least 1 meter long
- g) Other appropriate tools.

Chapter 12 : Procedures Under Abnormal Situations With  
Radiographic While In Operation

**39. X- Ray Equipment**

The following actions shall be taken by an operator/supervisor at the site in case of any abnormal situation with the x-ray equipment [P.U.(A)61 Regs. 30,31,43 and 55 and P.U.(A)149 Reg. 12(b):

- a) SWITCH OFF the machine.
- b) ENSURE that everything is at its position until otherwise decided by the RPO.
- c) ASK any person who may have been exposed to remain at the site for inquiry. Record their names, addresses, and telephone numbers.

- d) INFORM the person in charge of the site on what has happened.
- e) ENSURE that the x-ray machine is not moved in order to establish the extent of the exposures or if this unavoidable, its position should be marked to ensure that the conditions at the time of the abnormal situations can be reproduced.
- f) INFORM the RPO about the incident.

Upon arrival at the site, the RPO shall:

- a) MAKE a full investigation of the circumstances, taking written statements from workers involved, including details of where they were in relation to the x-ray machine, and for how long. Obtain similar information from members of the public who may have been exposed to the x-rays.
- b) REMOVE workers involved from radiation work, until their doses have been established.
- c) SEND their films badges to the approved laboratory (e.g. Nuclear Malaysia Agency) for urgent assessment.
- d) PREPARE a detailed written report to the Board regarding the incident which has occurred.

#### **40. Sealed Source**

40.1 The following actions shall be taken by the operator/supervisor in case of any abnormal situations with a sealed source [P.U.(A)61 Regs. 30,31,43 & 55 and P.U.(A)149 Reg. 12(b)]:

- a) MEASURE the radiation level with a survey meter and if necessary, establish a new boundary of the controlled area. If barrier materials are not available, “sentries” should be posted where the barriers should be. Notices and flashing lights should be displayed at the barrier positions.
- b) ASK any person who may have been exposed to remain at the site for inquiry. Record their names, addresses and the telephone numbers.
- c) INFORM the person in charge of the site on what has happened.
- d) Report the event to the RPO.
- e) While waiting arrival of the RPO, the operator/supervisor shall ensure that nobody enter the control area,

Action shall be taken by the RPO:

- a) PLAN course of actions to restore the condition into normal situation (actions to be taken varies according to condition of the abnormal situation). Example of actions to be taken in the case of source disconnected or stuck in the guide tube are as follows:
  - i). make an attempt to rescue the source and place it into the shielded container.
  - ii). if this attempt successful, the RPO shall take similar actions as in the case of x-ray equipment (paragraph 39.2 (a) – (d)). Apparatus for gamma radiography involved in this situation

shall be sent to the approved service center for evaluation.

- iii). if this attempt unsuccessful, immediately contact the Board for further assistant.
- b) IMPLEMENT the planned course of actions in accordance with the company's Radiation Protection Programme.
- c) Refer to x-ray equipment upon arrival of RPO. a) till d).

**Table 15:** *Source recovery*

| Source | Activity<br>(GBq) | Dose rate at 1 m<br>(mSv/hr) | Allowable time<br>(min) |
|--------|-------------------|------------------------------|-------------------------|
| Ir-192 | 37                | 4.8                          | 120                     |
|        | 74                | 9.6                          | 60                      |
|        | 185               | 24.0                         | 25                      |
|        | 370               | 48.0                         | 12                      |
|        | 740               | 96.0                         | 6                       |
|        | 1850              | 240.0                        | 2                       |
|        | 3700              | 480.0                        | 1                       |
| Co-60  | 37                | 13.2                         | 46                      |
|        | 74                | 26.4                         | 23                      |
|        | 185               | 66.0                         | 9                       |
|        | 370               | 132.0                        | 4.6                     |
|        | 740               | 264.0                        | 2.3                     |
|        | 1850              | 660.0                        | 0.9                     |
|        | 3700              | 1320.0                       | 0.4                     |

Note : The time column is derived from a dose of 10 mSv to the hands at 1 m.

40.2 Further action will depend on whether or not the source has been returned to its container the following actions shall be taken [P.U.(A)61 Regs. 30,31,43 and 55 and P.U.(A)149 Reg. 12(b)]:

- a) CHECK the shielding.
- b) CHECK the fastenings.
- c) PLACE the container in the store.
- d) MAKE a full investigation of the circumstances, taking written statements from the workers involved including details of where they were in relation to the source, and for how long. Obtain similar information from any member of the public who may have been exposed to the radiation.
- e) REMOVE all workers involved from radiation work until their doses have been established.
- f) SEND the film badges worn by all workers involved to the approved laboratory for urgent assessment.
- g) SUBMIT a detailed written report to the Board regarding the incident that had happened.

40.2.2 If the source is still outside its container the following actions shall be taken [P.U.(A)61 Regs. 30,31,43 and 55 and P.U.(A)149 Reg. 12(b)]:

- a) CHECK that the barriers, warning signals and notices area satisfactory and they are under control.
- b) MAKE a further attempt to return the source to its container. If this attempts fails, decide whether it is necessary to obtain another container.

WHEN THE SECOND CONTAINER IS AVAILABLE.

- a) PLACE the source in it.
- b) DECIDE whether the source can be returned to its container with the aid of handling facilities at the base or elsewhere, or whether disposal action is necessary. In the latter case, the Board shall be contacted immediately.
- c) SET in motion the series of all actions in 40.2.1.

#### **41. Pipeline Crawler Machine**

In case of any abnormal situations with a pipeline crawler machine, where the x-ray machine cannot be switched off or the source cannot be retracted, the procedures under abnormal situations of x-ray equipment (paragraph 39) and sealed source (paragraph 40) shall also be applied [P.U.(A)61 Regs. 30,31,43 & 55 and P.U.(A)149Reg. 12(b)].

Chapter 13: Procedures Under Abnormal Situations With Radiographic Equipment While Not In Operation

#### **42. Damage Or Malfunction**

Damage and/or malfunction radiographic equipment shall not be used under any circumstances. In case of damage and/or malfunction equipment RETURN the equipment to the approved laboratory for inspection, repair and subsequent certification.

#### **43. Sealed Source Involved in Fire**

In the event of fire, sealed source shall be removed from the area, if this can be done without risks. In other cases, they should be abandoned. AELB shall be informed immediately about this event. Fire service department shall also be informed of the presence of sealed source as soon as possible and action as in paragraph 40 shall be commenced [P.U.(A)61 Reg. 30, 31, 43 & 55 and P.U.(A)149 Reg. 12(b)].



#### **44. Theft or Loss Of Radiographic Equipment**

The following actions shall be taken upon discovering any theft or loss of any radiographic equipment [P.U.(A)61 Regs. 30 & 53].

- a) BEGIN an immediate search. In case of source loss in transport, retrace the exact route taken by the vehicle, making both a visual search for the radiographic equipment and an instrumental search for the radiation from the source; and
- b) INFORM the RPO who will make further attempt to search for the equipment.
- c) If the attempt is unsuccessful, INFORM the Board and police immediately.

#### **45. Accident While Transporting a Package Containing Sealed Source**

The following actions shall be taken immediately by radiation worker involved in an accident while transporting a package containing sealed source [P.U.(A)61 Regs. 31 and 53, P.U.(A)149 Reg. 12(6) and P.U.(A)456 Reg. 59].

- a) SURVEY the package containing sealed source to ensure that the sealed source is secured in its shielded position, if the vehicle is not involved in fire. If fire is involved, survey the area as close as possible to the package containing sealed source, to determine whether or not it is leaking.
- b) SET up the controlled area around vehicle, if the survey reveals package is leaking.
- c) KEEP the public away from the vehicle.
- d) NOTIFY the RPO.

The following actions shall be taken by RPO:

- a) NOTIFY the police of such accident.
- b) NOTIFY BOMBA, if need to do so.
- c) RECORD name, address and telephone number of any person who may have been exposed or contaminated. If any person has actually handled or has had any part of his body touched the leaking package containing sealed source, he shall be sent for decontamination immediately.

**46. General Requirements**

Whenever any person has reasonable cause to believe that he or any other person has received an overexposure during abnormal situations, he shall report the circumstances to the RPO or the supervisor [P.U.(A)61 Reg. 30]. The RPO or the supervisor shall take the following actions, depending on whether the suspected person are workers or members of the public [P.U.(A)61Regs. 30 and 31].

**46.1 For Workers**

- a) MAKE a full investigation of the circumstances, taking written statements, including details of where they were in relation to the radiographic equipment, and for how long.
- b) SEND their film badges to the approved laboratory for urgent assessment.
- c) REMOVE them from work involving ionizing radiation until their doses have been assessed.

Where the investigation confirms the report or there is another reason to believe that any person has received a dose in excess of the limits laid down in Table 1 in paragraph 6.2 the licensee shall immediately send the worker concerned to go for the special medical examination by an ARMP [P.U.(A)61 Regs. 30 & 31].:

If the exposed workers shows clinically observable injuries as a result or the overexposure, his duties may have to be modified to ensure that those injuries are not aggravated by his subsequent employment [P.U.(A)61 Regs. 40 & 42]. Prior approval from the Board shall be obtained before reemployment is permitted.

When it is recommended by ARMP that a worker who has incurred an overexposure be permitted to return to radiation work, the detailed reasons for the recommendation shall be recorded in the medical history of that worker [P.U.(A)61 Reg. 27].

**46.2 For members of the public**

- a) MAKE full investigation of the circumstances, taking written statements, including details of where they were in relation to the radiographic equipment and for how long [P.U.(A)61 Reg. 30].
- b) RECORD their names, addresses and telephone numbers so that they can be contacted if necessary.
- c) If the investigation indicates members of the public is suspected to have been overexposed, send the person for medical investigation. Inform the Board immediately about this particular action.

## REFERENCES

1. Atomic Energy Licensing Act 1984 (Act 304)
2. Radiation Protection (Licensing) Regulations 1986 [P.U.(A)149]
3. Radiation Protection (Basic Safety Standards) Regulations 1988 [P.U.(A)61]
4. Radiation Protection (Transport) Regulations 1990 [P.U.(A)456]
5. ICRP, Protection Against Ionizing Radiation From External Sources used in Medicine, Publication 33, Pergamom Press, Oxford and New York (1982)
6. ICRP, Data For Use in Protection Against External Radiation, Publication 51, Pergamom Press, oxford and New York (1988)
7. IAEA, Radiations Protection Procedure, Safety series No. 38 (1973)
8. IAEA, Safe Handling of Radionuclides Safety Series no. 1 (1973)
9. ISO, Specification for Apparatus for Gamma Radiography Publication ISO 3999 (1977)
10. Training Manual 2, Radiation Hazard Control in Industrial Radiaography, Minister of National Health & Welfare Canada (1982).
11. Safety in Industrial Radiography A Training Manual, NRL, New Zealand, ISSN 0111-753x (1981)
12. Radiation Safety For Site Radiography, kluwer Publishing Ltd. London
13. Taylor W.R., "Leakage Tests For Type B Package" Proceeding of a Seminar on Transport Packing For Radioactive Material, Vienna 23-27 August 1976. IAEA-SR-10/46 (pg 261-267)
14. Approved Code of Practice "The Protection of Persons Against Ionizing Radiation Arising From Any Work" The Ionizing Radiation Regulations 1985, London, ISBN 0118838385 (1989)
15. Martin A & Hasbison S.A An Introduction Protection, John Wiley & Sons, New York 1979
16. British Gas Engineering Standard BGC/PS/SEP2 "Safety Procedures for Personnel Entering and Working in Gas Transmission Pipelines"
17. Malaysian Standard "Specification for data on Shielding from Ionizing Radiation Part 1 : Shielding from Gamma Radiation MS 5.9:1974
18. ISO: Radioactive Materials- Packaged- Tests for Leakage and radiation leakage ISO 2855
19. American National Standard NA32 ; Radiological Safety for the Design and Construction of Apparatus for Gamma Radiography NBS Handbook 136
20. Bhabha Atomic Research Centre India, Procedures for Radiological Safety in Open Field Radiography, RPG/IND-3, 1983

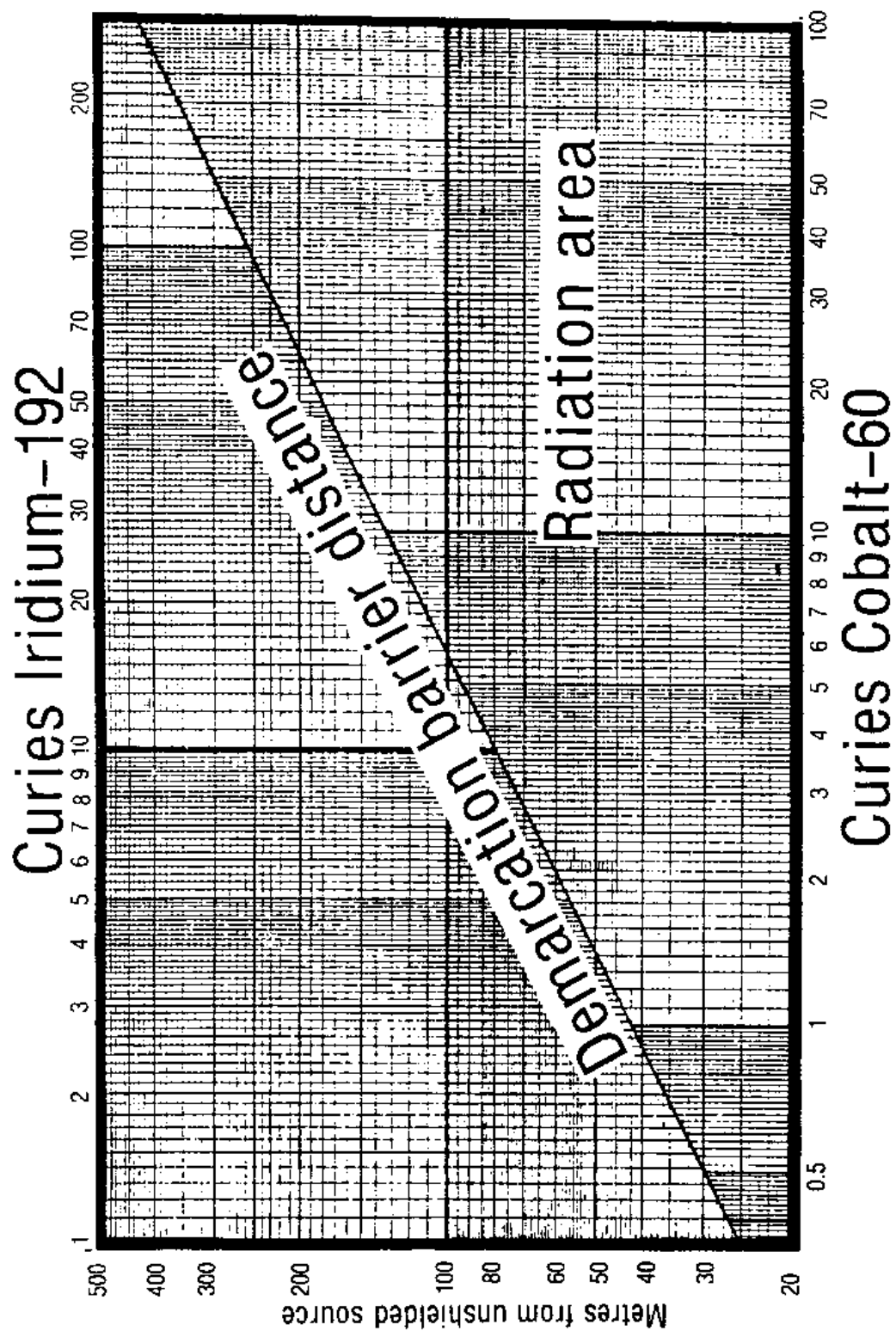


Figure 6: Barrier distances (For conversion to SI Units 1 Curie =  $3.7 \times 10^{10}$  becquerels (Bq).)

Figure 7

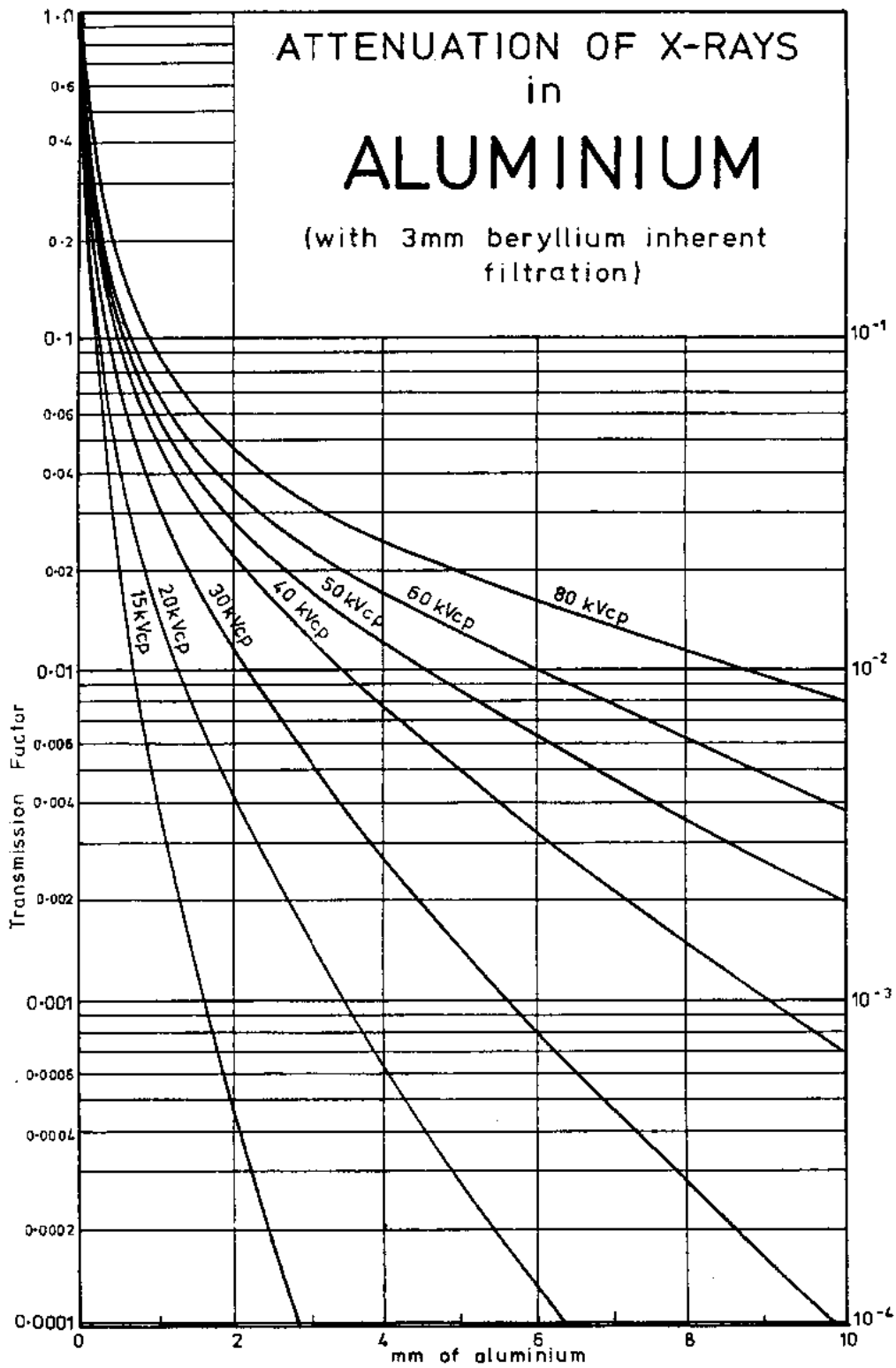


Figure 8

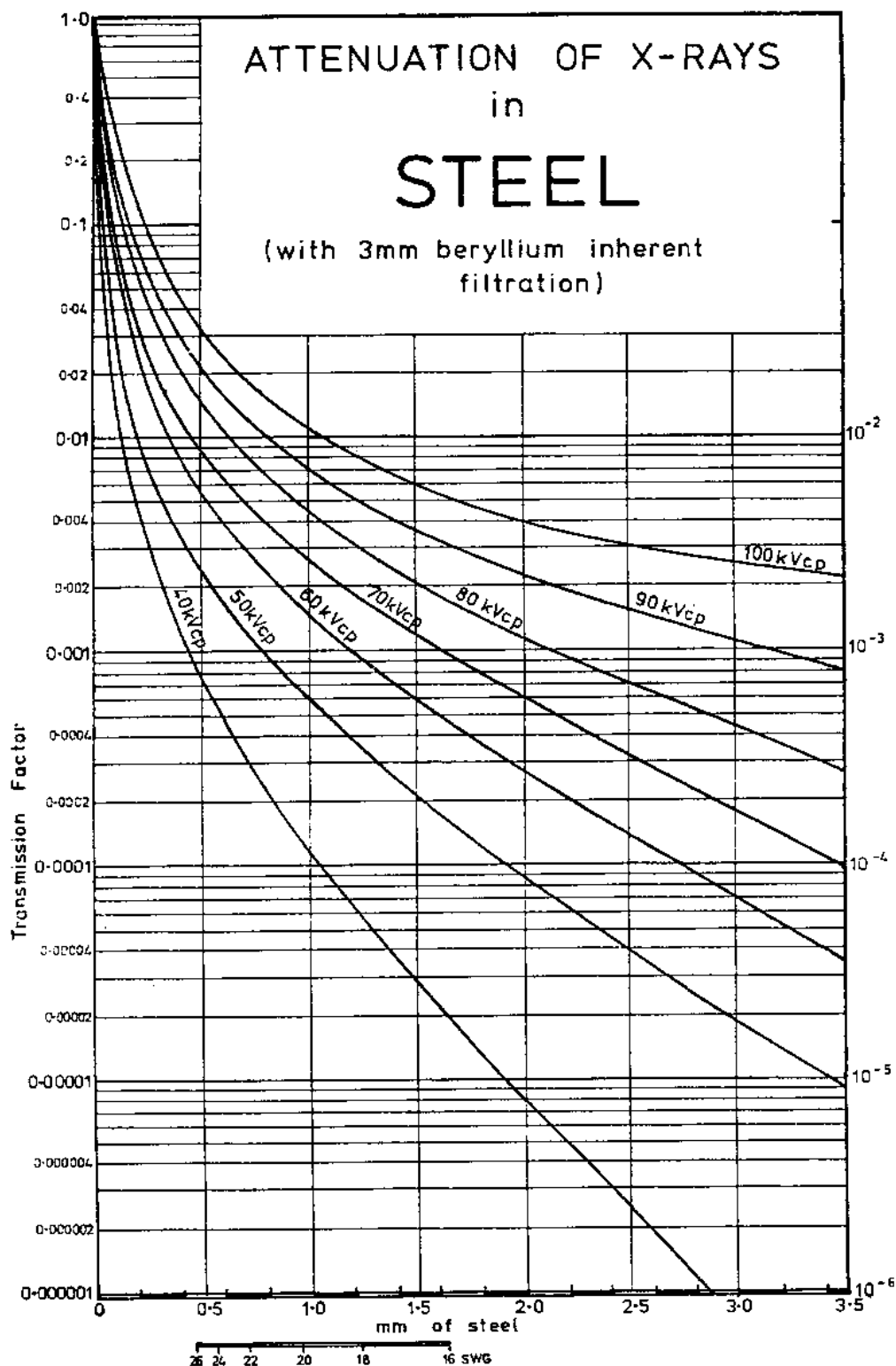


Figure 9

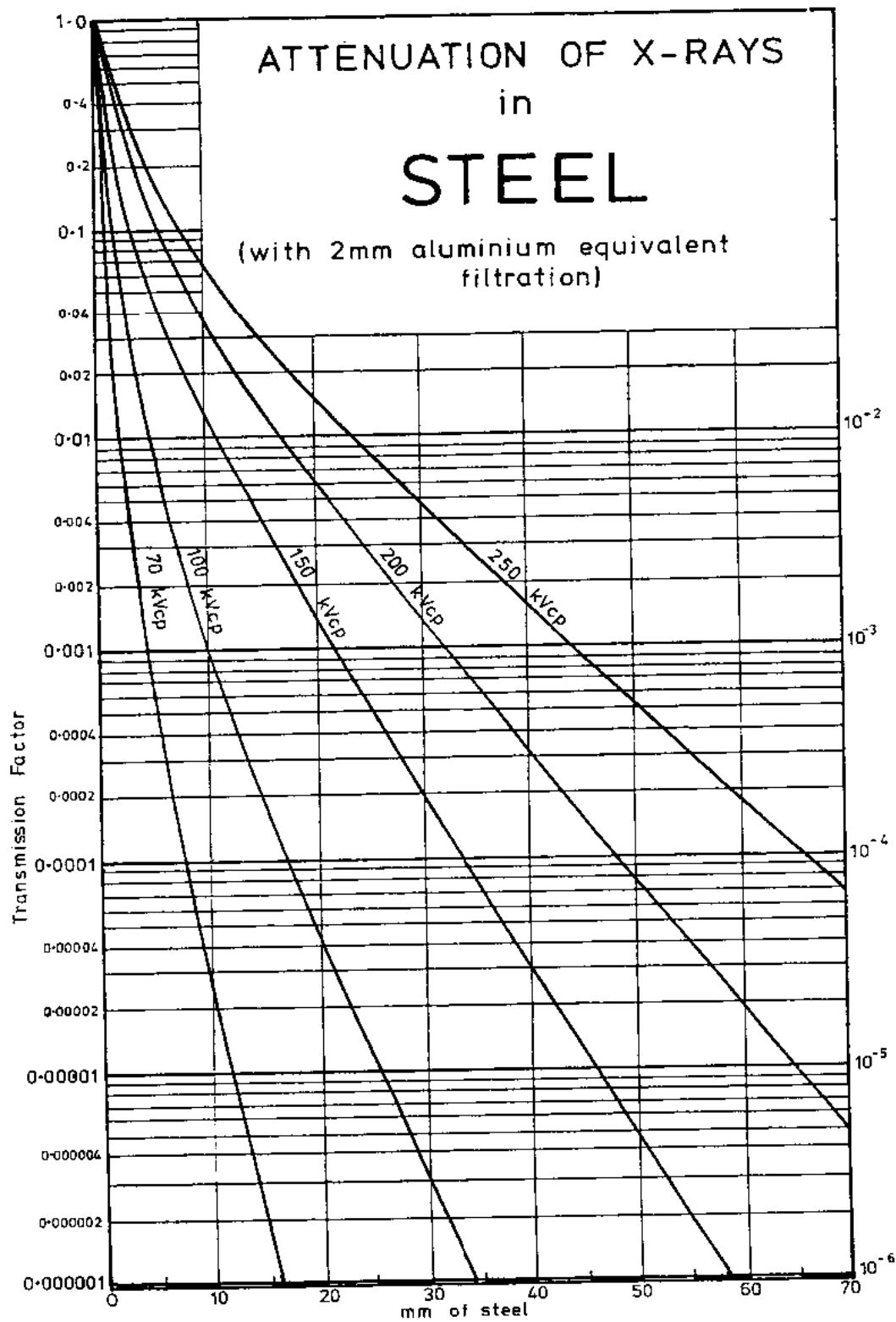


Figure 10

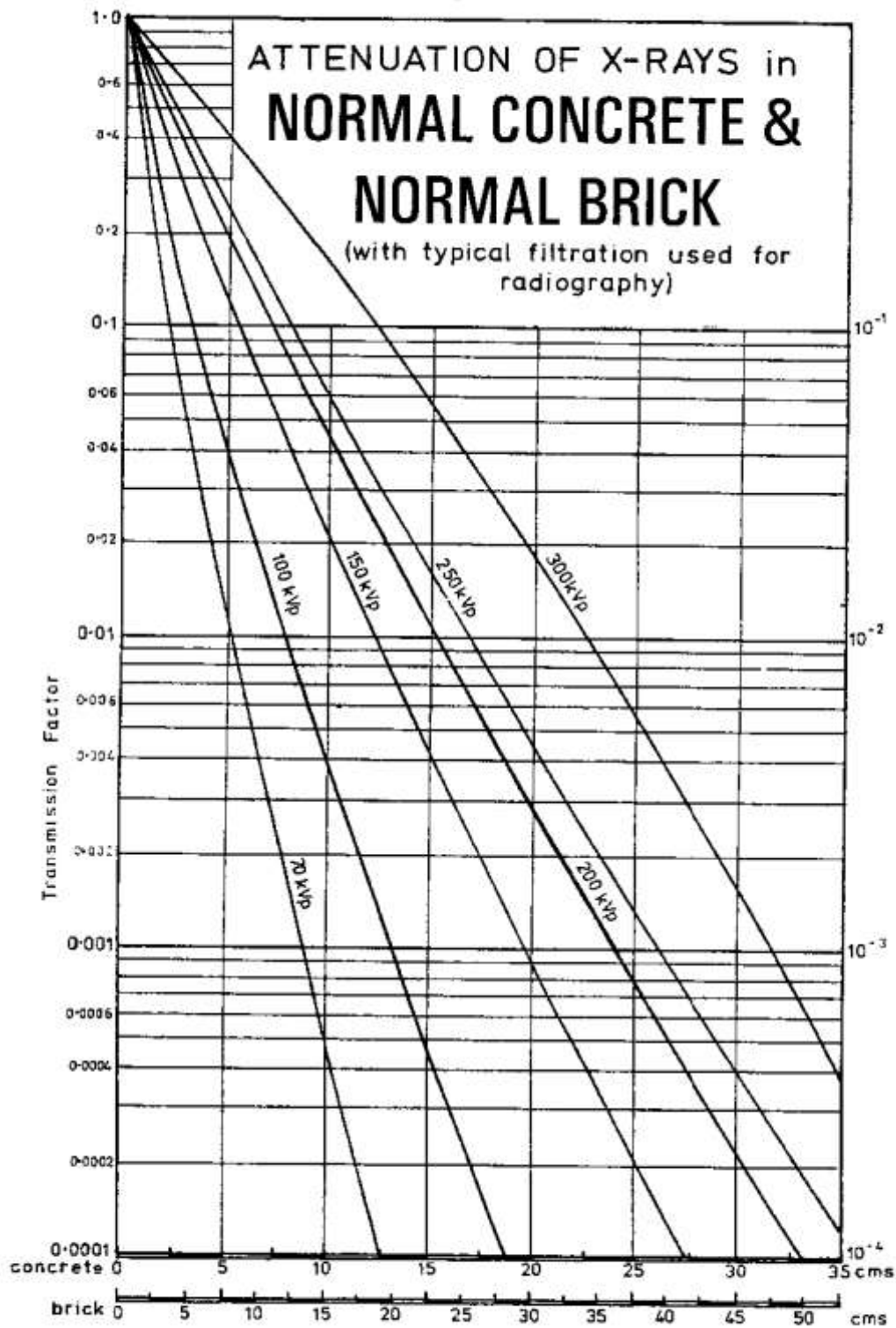




Figure 11

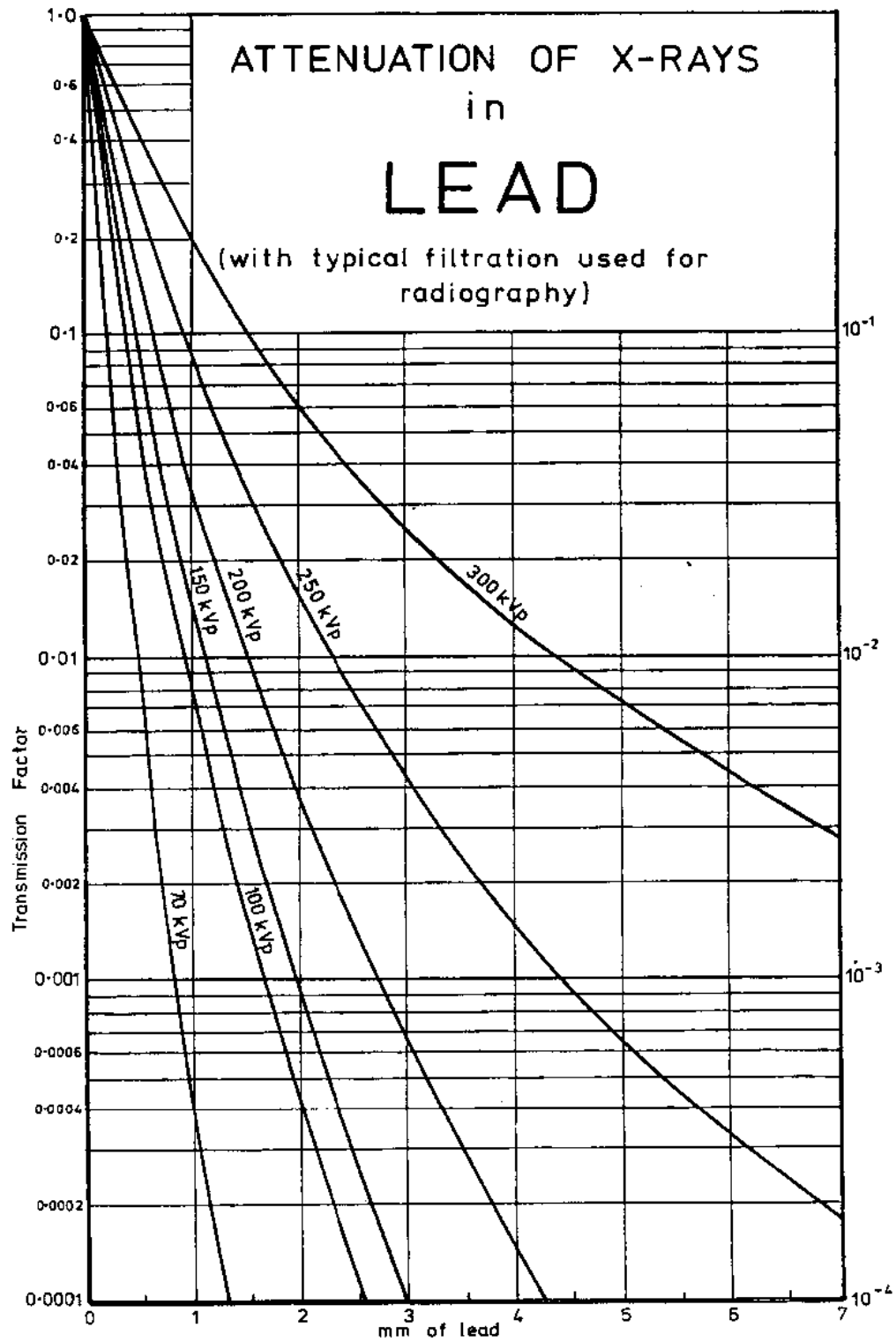


Figure 12

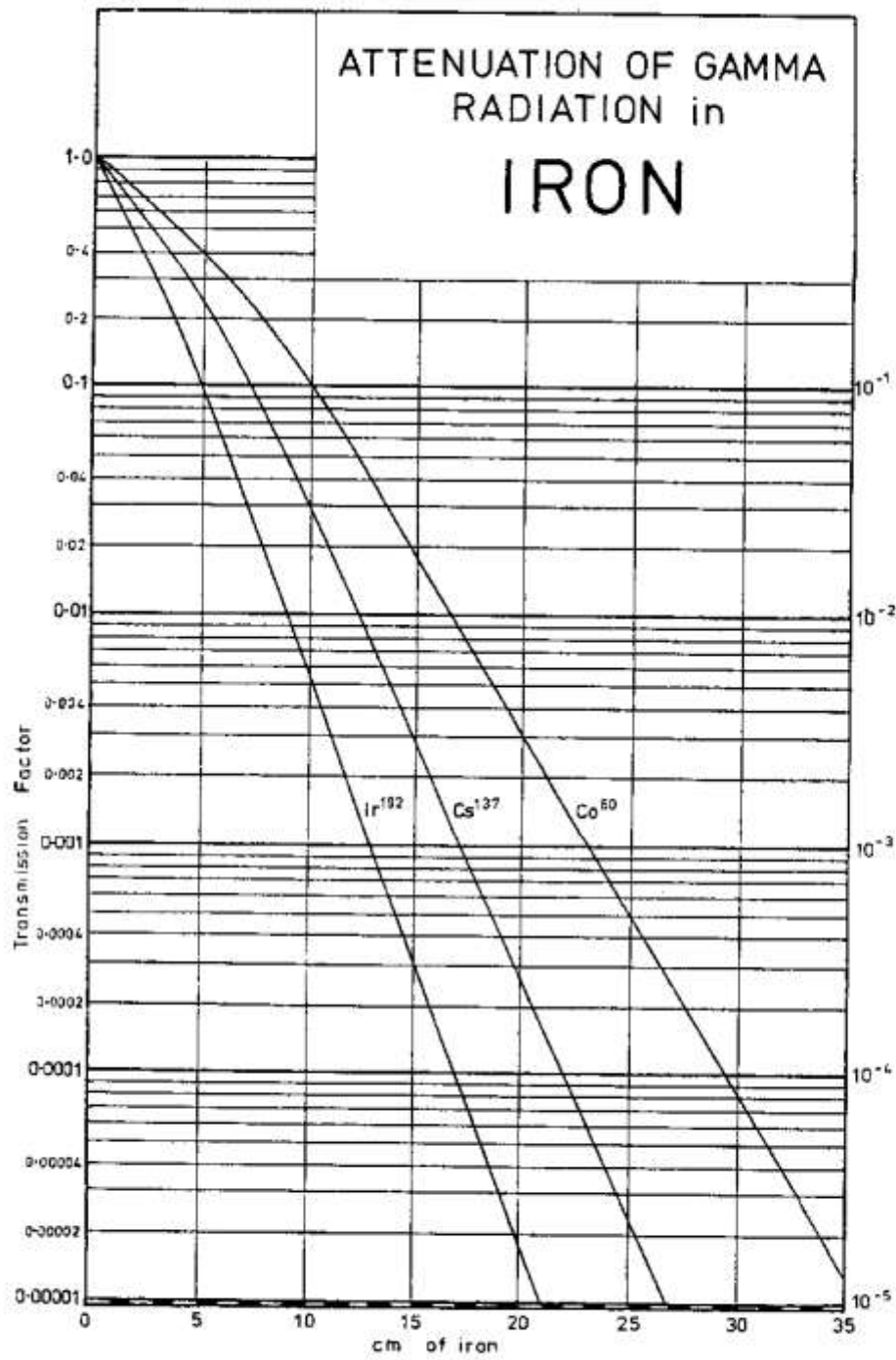


Figure 13

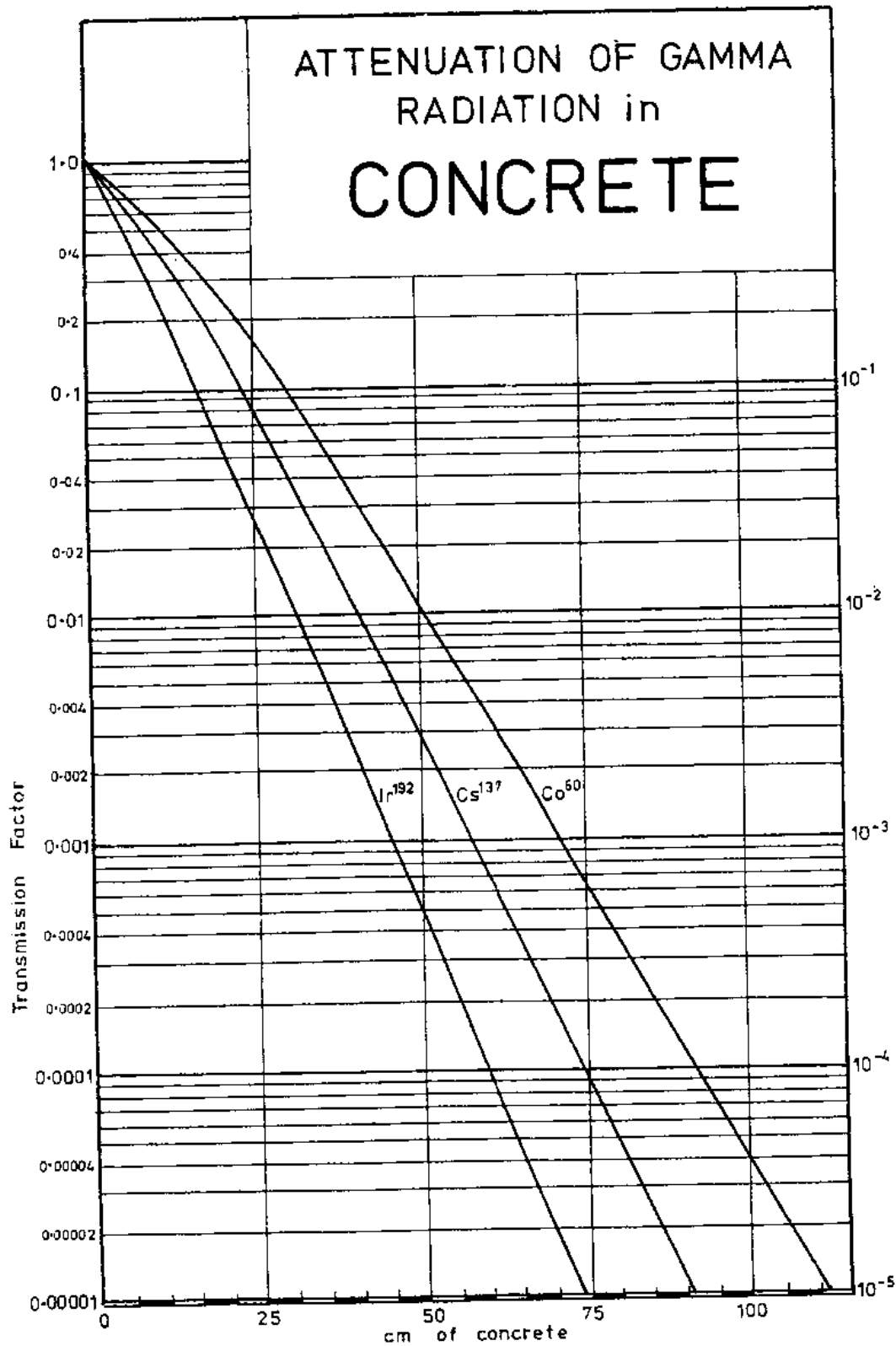
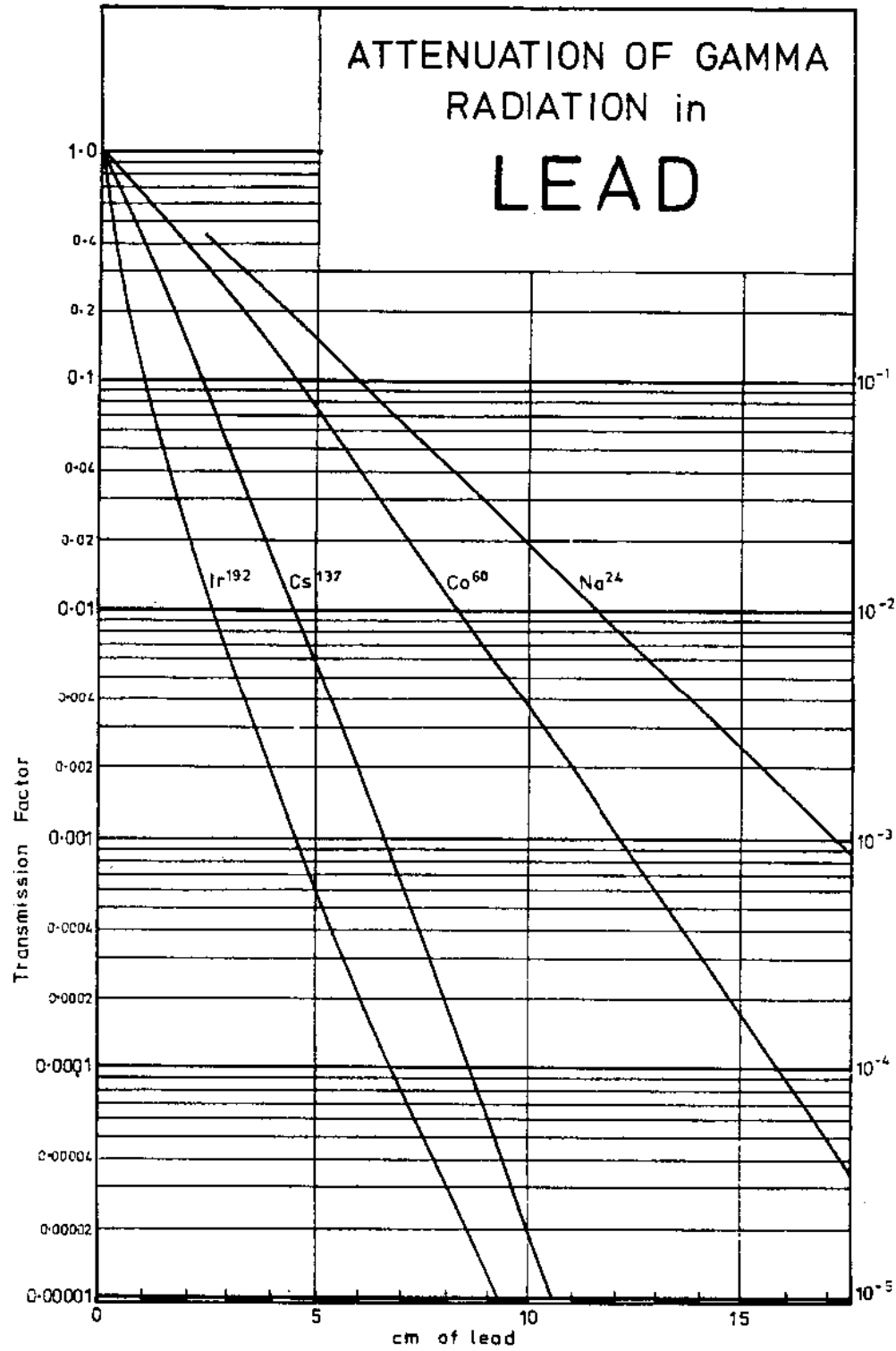


Figure 14



## APPENDIX 1

| <b>LEMBAGA PERLESENAN TENAGA ATOM</b><br><b>REKOD PERGERAKAN ISOTOP</b> |                      |                   |               |   |                          |   |                  |                |
|---|----------------------|-------------------|---------------|---|--------------------------|---|------------------|----------------|
| <b>A. Nama</b><br><br><b>Alamat Agensi</b>                              |                      |                   |               | <b>B. Nombor &amp; Kelas Lesen :</b><br><br><b>Tempoh Sah Lesen :</b> |                          |   |                  |                |
| Tarikh  | Unsur & Nombor Jisim | Nombor Siri Punca | Aktiviti (Bq) | Nombor Siri Bekas Pengangkutan  | Model Bekas Pengangkutan | Jenis & No. Kenderaan (Darat/Laut/Udara*) | Lokasi Dari mana | Lokasi Ke mana |
|   |                      |                   |               |   |                          |   |                  |                |

**C.**

Nama .....

No. Kad Pengenalan.....

Jawatan.....

**D.**

Tandatangan.....

Tarikh.....

Jika ruang tidak mencukupi sila gunakan lampiran. Borang ini hendaklah diisi dalam 2 salinan  
 \*Potong yang tidak berkenaan

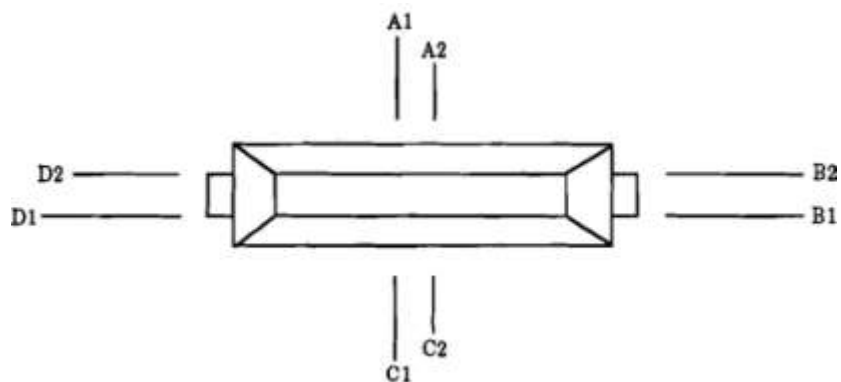
## APPENDIX 2

### LEMBAGA PERLESENAN TENAGA ATOM KEBOCORAN SINARAN RADIOGRAFI

|                               |                    |    |    |    |                 |    |    |    |              |
|-------------------------------|--------------------|----|----|----|-----------------|----|----|----|--------------|
| Nama & Alamat Pemegang Lesen: |                    |    |    |    | Punca:          |    |    |    |              |
| Nombor & Kelas Lesen:         |                    |    |    |    | No. Siri Punca: |    |    |    |              |
|                               |                    |    |    |    | Aktiviti:       |    |    |    |              |
|                               |                    |    |    |    | Model Bekas:    |    |    |    |              |
|                               |                    |    |    |    | No. Siri Bekas: |    |    |    |              |
| Kedudukan*                    | Paras Bacaan mR/hr |    |    |    |                 |    |    |    |              |
|                               | A1                 | B1 | C1 | D1 | A2              | B2 | C2 | D2 | Diukur oleh: |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |
|                               |                    |    |    |    |                 |    |    |    |              |

NOTA : Pengukuran hendaklah dibuat sekurang-kurangnya sekali dalam masa tujuh hari.

\* Pandangan alat dedahan radiografi dari atas :



Skil : A1,B1,C1,D1 = 1 cm  
A2, B2, C2, D2 = 5 cm

### APPENDIX 3

#### LEMBAGA PERLESENAN TENAGA ATOM,

#### REKOD LENCANA FILEM INDIVIDU

NAMA PEKERJA &  
NO.K/P : \_\_\_\_\_ NO.LESEN : \_\_\_\_\_

TARIKH LAHIR : \_\_\_\_\_ NAMA & ALAMAT  
PEMEGANG LESEN : \_\_\_\_\_

TARIKH AKHIR PEMERIKSAAN PERUBATAN: \_\_\_\_\_

MULAI: \_\_\_\_\_

| NO.LENCANA<br>FILEM | TARIKH<br>ISU | TARIKH<br>PEMULANGAN | DOS UNTUK 1 TAHUN<br>KALENDER |           | ULASAN | T/TANGAN<br>PEKERJA |
|---------------------|---------------|----------------------|-------------------------------|-----------|--------|---------------------|
|                     |               |                      | SEMASA                        | TERKUMPUL |        |                     |
| 1.                  |               |                      |                               |           |        |                     |
| 2.                  |               |                      |                               |           |        |                     |
| 3.                  |               |                      |                               |           |        |                     |
| 4.                  |               |                      |                               |           |        |                     |
| 5.                  |               |                      |                               |           |        |                     |
| 6.                  |               |                      |                               |           |        |                     |
| 7.                  |               |                      |                               |           |        |                     |
| 8.                  |               |                      |                               |           |        |                     |
| 9.                  |               |                      |                               |           |        |                     |
| 10.                 |               |                      |                               |           |        |                     |
| 11.                 |               |                      |                               |           |        |                     |
| 12.                 |               |                      |                               |           |        |                     |
| 13.                 |               |                      |                               |           |        |                     |
| 14.                 |               |                      |                               |           |        |                     |

PERINGATAN : Pemegang lesen hendaklah memberitahu setiap pekerja secara bertulis mengenai keterangan pemantauan kakitangannya status dedahan sinaran tidak lewat dari 2 minggu selepas tarikh keputusan diperolehi.

## APPENDIX 4

| <b>LEMBAGA PERLESENAN TENAGA ATOM</b><br><b>KEMENTERIAN SAINS, TEKNOLOGI DAN INOVASI</b><br><b>PERMOHONAN KEBENARAN AKTIVITI</b><br><b>PERGERAKAN BAHAN RADIOAKTIF</b>  |   |
|---|---|
| A. Nama dan Alamat Syarikat/Agensi:   | B. Nombor Pendaftaran/Lesen LPTA: .....   |
|   | C. Butir-butir bekas pengangkutan:<br>i. No. Siri : .....<br>ii. Model : .....<br>iii. Tarikh tamat sijil : ..... |
| D. Butir-butir berkenaan bahan radioaktif (Terkedap/ Tidak terkedap)*<br><br>i. Unsur & No. jisim/ Mineral : .....<br>ii. Aktiviti punca/ Mineral : .....<br>iii. No. siri punca : .....<br>iv. Tarikh tamat sijil : .....<br>v. Jumlah/ kuantiti : .....   |   |
| E. Tarikh dijangka pergerakan*:   |   |
| F. Destinasi pergerakan/ dari mana diimport*:   |   |
| G. Jumlah bahan radioaktif (unsur dan No. jisim) yang sedia ada:  |   |
| H. Nyatakan pintu masuk/ keluar*:   |   |
| I. Pengesahan Pegawai Perlindungan Sinaran/ Penyelia/ Orang Bertanggungjawab Terhadap Pendaftaran/Lesen*<br><br>i. Nama : .....<br>ii. No. Kad Pengenalan/ Pasport*: .....<br>iii. No. telefon/fak/e-mel:.....<br><br>Tarikh : .....<br><div style="text-align: right;">Tandatangan &amp; Cop Syarikat/Agensi</div>   |   |
| UNTUK KEGUNAAN PEJABAT  |   |
| 1. Lulus/Gagal* Bil: .....<br>2. Kelulusan sah sehingga : .....<br><br>Nama : .....<br>Tarikh : .....<br><div style="text-align: right;">Bahagian Penguatkuasaan<br/>b/p Ketua Pengarah</div>   |   |
| -Potong (*) pada yang tidak berkenaan..<br>-Tulis TB pada ruang yang tidak berkaitan.<br>-Sila gunakan lampiran jika ruang tidak mencukupi.<br>-Borang yang telah lengkap diisi hendaklah disertakan bersama yuran perkhidmatan <b>RM20.00</b> sama ada dalam bentuk tunai, bank draf, kiriman wang atau wang pos. Bagi bayaran secara bank draf, kiriman wang atau wang pos, ianya hendaklah dibuat atas nama Ketua Pengarah AELB..<br>-Permohonan hendaklah dikemukakan tidak kurang <b>14 hari</b> sebelum tarikh import/eksport hendak dilakukan. | <b>MALAYSIA</b>   |



LEMBAGA PERLESENAN TENAGA ATOM  
KEMENTERIAN SAINS, TEKNOLOGI DAN INOVASI

PERINGATAN\* : - Potong yang tidak berkenaan  
- Jika ruang tidak mencukupi sila gunakan lampiran  
- Borang ini hendaklah diisi dalam tiga (3) salinan

## APPENDIX 6

### SENARAI PEMERIKSAAN PENGANGKUTAN BUNGKUSAN MENGANDUNGI PUNCA TERKEDAP UNTUK TUJUAN RADIOGRAFI INDUSTRI

#### AKTA PERLESENAN TENAGA ATOM 1984 (AKTA 304)

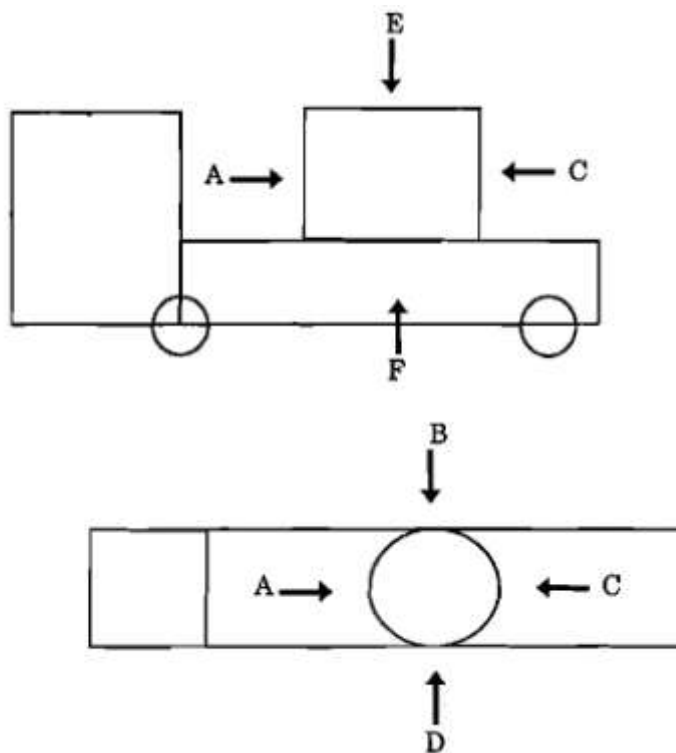
Tandakan (/) di ruangan yang berkaitan

|                                     |                              |
|-------------------------------------|------------------------------|
| TEMPAT PERMULAAN : .....            | TEMPAT KETIBAAN : .....      |
| .....                               | .....                        |
| NAMA & ALAMAT PEMEGANG LESEN: ..... | TARIKH PENGANGKUTAN (DI      |
| .....                               | JANGKA) : .....              |
| .....                               | BIL. PEKERJA YANG TERLIBAT : |
| PEG. PERLINDUNGAN SINARAN (PPS)/    | AHLI RADIOGRAFI : .....      |
| PENYELIA BERTANGGUNGJAWAB : .....   | PEM. RADIOGRAFI : .....      |
| .....                               | PELATIH : .....              |
| .....                               |                              |

| I. PENTADBIRAN  | YA    | TIDAK | CATITAN |
|---|-------|-------|---------|
| 1. PPS/ PENYELIA dilantik secara bertulis   | ..... | ..... | .....   |
| 2. Pekerja diiktiraf secara bertulis  | ..... | ..... | .....   |
| 3. Prosedur pengangkutan tersedia ada.  | ..... | ..... | .....   |
| 4. Panduan operasi/penyelenggaraan bekas tersedia ada [senaraikan panduan yang hilang]. | ..... | ..... | .....   |
| 5. Alat yang berkaitan dan peralatan pengendalian bekas dedahan tersedia ada :          |       |       |         |
| (a) Tali yang cukup panjang   | ..... | ..... | .....   |
| (b) Lambang amaran sinaran/notis  | ..... | ..... | .....   |
| II. PUNCA TERKEDAP  |       |       |         |
| Bilangan diangkut   | ..... | ..... | .....   |
| Unsur & Sebatian  | ..... | ..... | .....   |
| Nombor Siri   | ..... | ..... | .....   |
| Carta penyusutan tersedia ada   | ..... | ..... | .....   |
| III. BEKAS PENGANGKUTAN   |       |       |         |
| Bilangan diangkut   | ..... | ..... | .....   |
| Jenis   | ..... | ..... | .....   |
| Nombor Siri   | ..... | ..... | .....   |
| Kadar dos maksimum dipermukaan  | ..... | ..... | .....   |
| Lambang Sinaran   | ..... | ..... | .....   |
| Tag isotop  | ..... | ..... | .....   |
| Palam perkapalan (Shipping plug)  | ..... | ..... | .....   |
| Penutup penstoran (Storage Cover)   | ..... | ..... | .....   |
| Berkunci  | ..... | ..... | .....   |

|  | YA    | TIDAK | CATITAN |
|--|-------|-------|---------|
| Kunci Berfungsi  | ..... | ..... | .....   |
| Gelung Pemilih berfungsi<br>(Selector ring function)         | ..... | ..... | .....   |
| Periksa celah GO-NO-GO<br>(GO-NO-GO slot check)              | ..... | ..... | .....   |
| Skrus di keadaan betul                                       | ..... | ..... | .....   |
| <b>IV. PEMACU PEMUTAR<br/>(WINDOUT GEAR)</b>                 |       |       |         |
| Bilangan diangkut  | ..... | ..... | .....   |
| Keadaan kabel  | ..... | ..... | .....   |
| Rahang & kalung  | ..... | ..... | .....   |
| Getah pelindung  | ..... | ..... | .....   |
| Operasi kendalian  | ..... | ..... | .....   |
| Fungsi Penutup   | ..... | ..... | .....   |
| Periksa Injap  | ..... | ..... | .....   |
| GO-NO-GO   | ..... | ..... | .....   |
| Penyambung mal<br>(Male connector)                           | ..... | ..... | .....   |
| Lubang   | ..... | ..... | .....   |
| Celah  | ..... | ..... | .....   |
| Fungsi pembilang   | ..... | ..... | .....   |
| Keadaan  | ..... | ..... | .....   |
| Skrus di keadaan betul                                       | ..... | ..... | .....   |
| <b>V. TIUB DEPAN DAN PEMANDU<br/>(FRONT AND GUIDE TUBES)</b> |       |       |         |
| Bilangan diangkut  | ..... | ..... | .....   |
| Tidak bengkok  | ..... | ..... | .....   |
| Keadaan am   | ..... | ..... | .....   |
| <b>VII. PEMONITORAN KAKITANGAN</b>                           |       |       |         |
| Menggunakan lencana filem                                    | ..... | ..... | .....   |
| Menggunakan dosimeter  | ..... | ..... | .....   |
| Menggunakan “audible alarm monitor”                          | ..... | ..... | .....   |
| <b>VIII. KENDERAAN</b>                                       |       |       |         |
| Nombor Pendaftaran   | ..... | ..... | .....   |
| Pembuat  | ..... | ..... | .....   |
| Umur   | ..... | ..... | .....   |
| Keadaan am   | ..... | ..... | .....   |
| Logo Syarikat  | ..... | ..... | .....   |
| Pelekat Disediakan ?   | ..... | ..... | .....   |
| Notis Standard Disediakan?                                   | ..... | ..... | .....   |
| Menggunakan Kotak Transit?                                   | ..... | ..... | .....   |

|               | nilai diukur |              |         |
|---------------|--------------|--------------|---------|
|               | di permukaan | di jarak 1 m | catatan |
| A             |              |              |         |
| B             |              |              |         |
| C             |              |              |         |
| D             |              |              |         |
| E             |              |              |         |
| F             |              |              |         |
| nilai maksima |              |              |         |



Ulasan keseluruhan :

.....Baik

.....Tidak Baik

Disahkan:.....

Tarikh pengesahan : .....

Cop : .....

## APPENDIX 7

### DOKUMEN PENGANGKUTAN BAHAN RADIOAKTIF MELALUI JALAN / REL

#### PERATURAN- PERATURAN PERLINDUNGAN SINARAN (PENGANGKUTAN) 1989

Dalam kes kecemasan sila hubungi:

Lembaga Perlesenan Tenaga Atom  
Batu 24, Jalan Dengkil,  
43800 Dengkil,  
Selangor Darul Ehsan

Tel : 03-89225888

Fax : 03-89223685

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 1. No. Lesen : .....<br>Tarikh mula : .....<br>Tarikh tamat : .....<br>Kelas Lesen : .....  | 2. Nama pemegang lesen : .....<br>Alamat kemudahan / premis : .....<br>Tel : .....  |   |   |   |   |
| 3. Nama Pegawai Perlindungan Sinaran : .....<br>No. K/P @ passport : .....<br>Tel : .....   | 4. Nama pemandu : .....<br>No. K/P @ passport : .....<br>Destinasi: .....<br>Dari : ..... Ke : .....<br>(pengirim) (penerima) |   |   |   |   |
| 5. No. Kenderaan : .....  |   |   |   |   |   |
| BAHAN RADIOAKTIF YANG DIANGKUT  |   |   |   |   |   |
| Unsur dan No. Jisim   | 1   | 2 | 3 | 4 | 5 |
| A. BENTUK FIZIKAL/KIMIKAL<br>B. AKTIVITI MAKSIMA<br>(pada tarikh _/_/_)<br>C. NO. SIRI PUNCA<br>D. NO. SIRI BEKAS PENGANGKUTAN<br>E. MODEL BEKAS PENGANGKUTAN<br>F. KATEGORI BUNGKUSAN<br>G. INDEKS PENGANKUTAN<br>H. DOS PERMUKAAN (MAKSIMA) |   |   |   |   |   |

PENGAKUAN : \* Saya dengan ini mengakui bahaya kandungan bungkusan ini telah diterangkan dengan betul dengan nama dan telah dibungkus, ditanda dan adalah dalam keadaan yang sesuai bagi pengangkutan selaras dengan Peraturan- peraturan Perlindungan Sinaran (Pengangkutan) 1989.

\_\_\_\_\_  
T/tangan Pengirim

\_\_\_\_\_  
Alamat Pengirim

\_\_\_\_\_  
No.Telefon Pengirim

## APPENDIX 8

### CONVERSION FACTORS FOR S.I UNITS

| Radiological Old unit quantity                 | Old unit   | Unit S. I.   | Relationship between units  |
|--|--|--|---|
| Activity of a radioactive material<br>Exposure | The curie<br>$1 \text{ Ci} = 3.7 \times 10^{10} \text{ dis/S}$   | The Becquerel<br>$1 \text{ Bq} = 1 \text{ disintegration/s}$<br>$10^3 \text{ Bq} = 1 \text{ kilobecquerel (kBq)}$<br>$10^6 \text{ Bq} = 1 \text{ megabecquerel (MBq)}$<br>$10^9 \text{ Bq} = 1 \text{ gigabecquerel (GBq)}$<br>$10^{12} \text{ Bq} = 1 \text{ terabecquerel (TBq)}$<br>$10^{16} \text{ Bq} = 1 \text{ petabecquerel (PBq)}$<br>$10^{18} \text{ Bq} = 1 \text{ exabecquerel (Ebq)}$ | $1 \text{ Bq} = 2.7 \times 10^{-11} \text{ Ci}$<br>$1 \text{ kBq} = 2.7 \times 10^{-8} \text{ Ci}$<br>$1 \text{ MBq} = 2.7 \times 10^{-5} \text{ Ci}$<br>$= 2.7 \text{ uCi}$<br>$1 \text{ GBq} = 27 \text{ mCi}$<br>$1 \text{ TBq} = 27 \text{ kCi}$<br>$1 \text{ PBq} = 27 \text{ kCi}$<br>$1 \text{ EBq} = 27 \text{ MCi}$<br>$1 \text{ uCi} = 37 \text{ kBq}$<br>$1 \text{ mCi} = 37 \text{ MBq}$<br>$1 \text{ Ci} = 37 \text{ GBq}$<br>$10^3 \text{ Ci} = 37 \text{ TBq}$<br>$10^6 \text{ Ci} = 37 \text{ PBq}$<br>$10^9 \text{ Ci} = 37 \text{ EBq}$ |
| Exposure                                       | The roentgen<br>$1 \text{ R} = \text{the production of ion (of one sign) carrying a charge of } 2.58 \times 10^{-4} \text{ C/kg of air}$ | No special named unit for exposure. The unit for ionization is $\text{C/kg}$ and this can be used to express the results of ionization chamber measurements as an intermediate step in the determination of absorbed dose.   |   |
| Absorbed dose                                  | The rad<br>$1 \text{ rad} = 0.01 \text{ J/kg}$   | The gray<br>$1 \text{ Gy} = 1 \text{ J/kg}$<br>$1 \text{ Gy} = 10^3 \text{ mGy} = 10^4 \text{ uGy}$  | $1 \text{ uGy} = 0.1 \text{ mrad}$<br>$1 \text{ mGy} = 100 \text{ mrad}$<br>$1 \text{ Gy} = 100 \text{ rad}$<br>$1 \text{ mrad} = 10 \text{ pGy}$<br>$1 \text{ rad} = 10 \text{ mGy}$<br>$100 \text{ rad} = 1 \text{ Gy}$   |
| Dose equivalent                                | The rem<br>$1 \text{ Rem} = 1 \text{ Rad} \times Q$<br>$Q$ adalah faktor kualiti   | The sievert<br>$1 \text{ Sv} = 1 \text{ Gy} \times Q \times N$<br>$1 \text{ Sv} = 10^3 \text{ mSv} = 10^6 \text{ uSv}$<br>$N$ is the product of all other modifying factors (currently taken as 1 by ICRP)   | $1 \text{ uSv} = 0.1 \text{ mrem}$<br>$1 \text{ mSv} = 100 \text{ mrem}$<br>$1 \text{ Sv} = 100 \text{ rem}$<br>$1 \text{ mrem} = 10 \text{ uSv}$<br>$1 \text{ rem} = 10 \text{ mSv}$<br>$100 \text{ rem} = 1 \text{ Sv}$   |

Note : 1 rem is equivalent to 1 rad  
(for x and gamma rays only)